POWER

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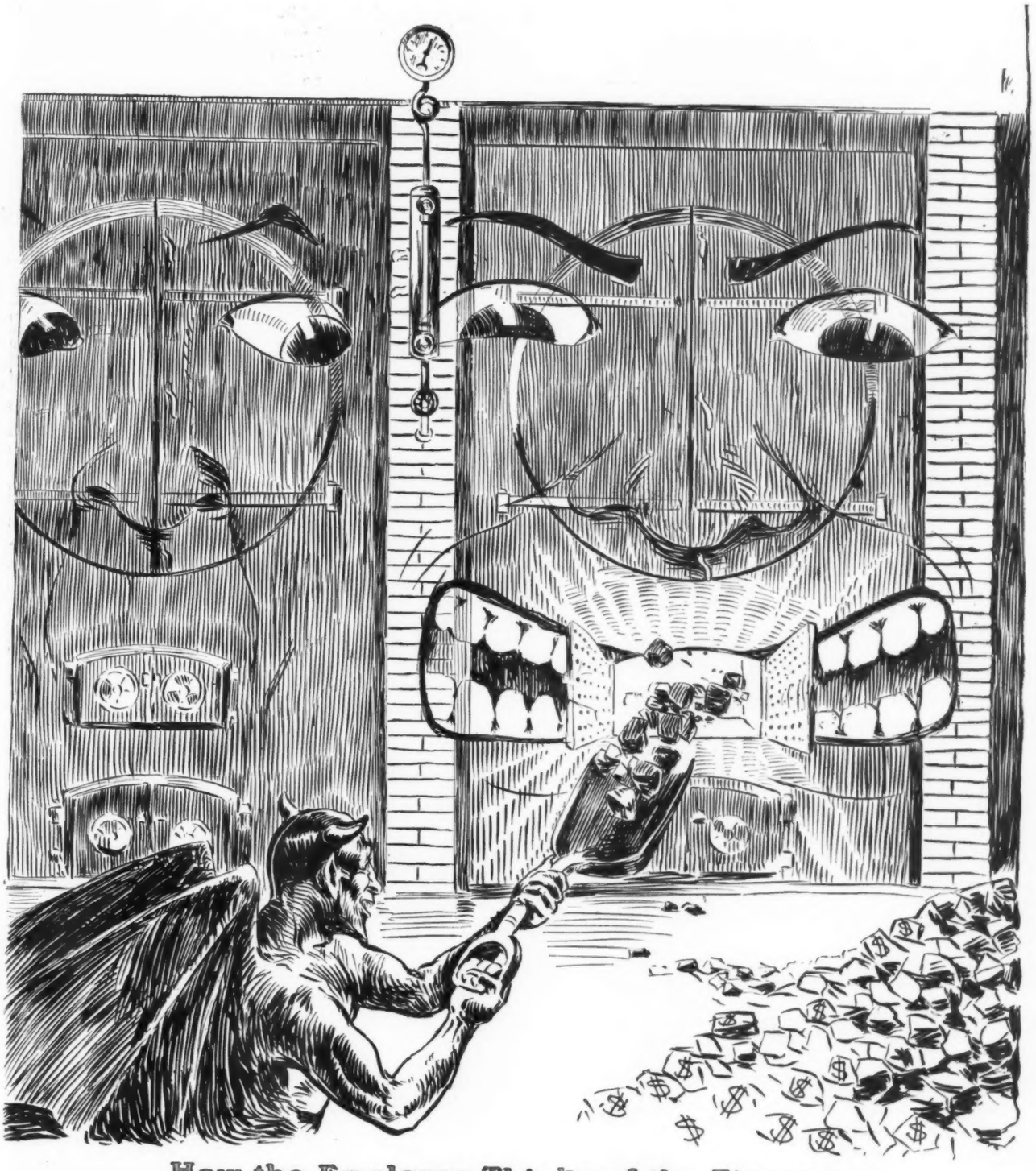


How the Employer Thinks of the Fireman

Extension of the Cos Cob Plant

By Warren O. Rogers

SYNOPSIS—The chief features of the station equipment are water-tube boilers having superheating coils, and eight steam turbines consisting of three 3750-kv.-a., four 5000-kv.-a. and one 4250-kv.-a. units; a combined forced- and natural-draft system is operated with the new boilers, the forced-draft fans being turbine driven and the first to operate with a reducing gear between the fan and turbine.

It is doubtful if any steam-power plant in this country operates with so much depending on continuity of service as the one at Cos Cob, Conn., which supplies electrical energy to the New York, New Haven & Hartford R.R.

When the Cos Cob plant was first built and the New Haven system was electrified as far as Stamford, Conn., 11,000 volts, single-phase, was the working voltage of the generators and on the lines. The voltage was supplied from the generator terminals to the contact wires without the aid of transformers. As this was a departure from existing practice, new problems and difficulties, naturally, were introduced, but the system was developed and the difficulties were overcome with two exceptions. One was that of electro-magnetic disturbances in neighboring telegraph and telephone circuits paralleling the railroad tracks. This disturbance had been corrected in a measure, but with the necessity of using larger currents as traffic increased, the adding of neutralizing transformers and other corrective apparatus did not appear satisfactory.

The other need was in relation to transmission voltages, and as it was planned to extend the electrification of the New Haven lines to New Haven, a distance of 45 miles, as well as to take on the Harlem River branch and freight yards, it was necessary to add to the original plant the turbines and boilers required to carry the increased load. There were difficulties in the way of raising the transmission voltage, because about 350 miles of overhead-contact wire insulation, together with rolling stock and other apparatus, would require replacing.

Under the old system all of the current flowing in either the overhead wire, the rails or ground return was in the same direction for the greater part of the trackage involved. With the new arrangement the generators at the power house do not directly feed the contact wire, but are connected to 22,000-volt auto-transformers at the power house, which have their centers grounded to the rails; the terminal voltage of the generators is, as formerly, 11,000 volts. One terminal of the transformer is carried to the contact wire and the other to feeder wires.

Turbine Plant

Two views of the turbine room are shown in Fig. 1, in which there are eight horizontal steam turbines with a total rated capacity of 35,500 kv.-a.; single-phase, 25-cycle current is used for railroad electrification, but three-phase for the other transmission.

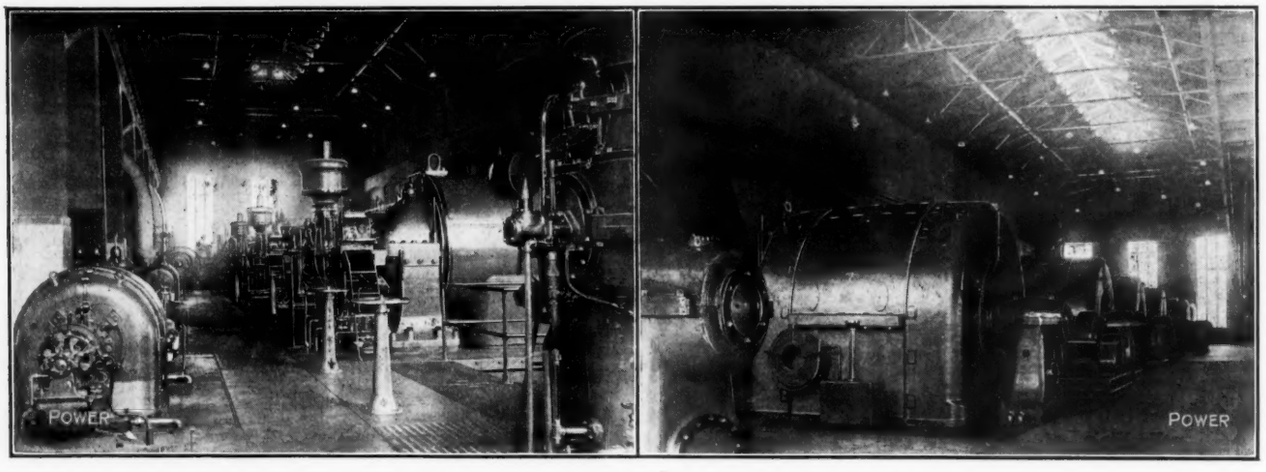


Fig. 1. Two Views of the Cos Cob Turbine Room

The turbines of the old station are connected to surface condensers having engine-driven circulating and independent air pumps. The four new turbines exhaust into jet condensers. Fig. 2 shows an elevation of the piping and arrangement of the condensers in the basement. Fig. 3 is a side elevation of the new boiler room.

Exciter current is furnished for the generators in the old plant by two 12 and 22 by 13-in. compound-vertical engines, each directly driving a 125-kw., 125-volt, direct-current generator. For the new units there are two turbine-driven, 125-kw., 125-volt generators driven through a reducing gear from one turbine. There is also one 125-kw., 125-volt generator driven by a 190-hp., 440-volt induction motor at 480 r.p.m. and one 175-kw., 125-volt generator driven by a 260-hp., 440-volt induction motor at 480 r.p.m.

Along one side of the turbine room are two turbo-generators of 130-kw. capacity, each delivering 2300-volt, single-phase, 60-cycle alternating current at 3600 r.p.m. The electrical energy developed by these units and from a motor-driven set consisting of a 500-hp., 440-volt induc-

tion motor and a 450-kv.-a., 2300-volt alternating current, three-phase, 60-cycle generator at 720 r.p.m., is for operating railway signals. The plan view, Fig. 4, shows the location of the various units in the new half of the plant. There is a noticeable absence of piping in the fan placed above the boilers and between the economizers and the stack. The furnace gases from eight boilers pass through two economizers and those of the other six pass through but one before going to the fan and stack.

In the boiler-room addition there are 14 water-tube

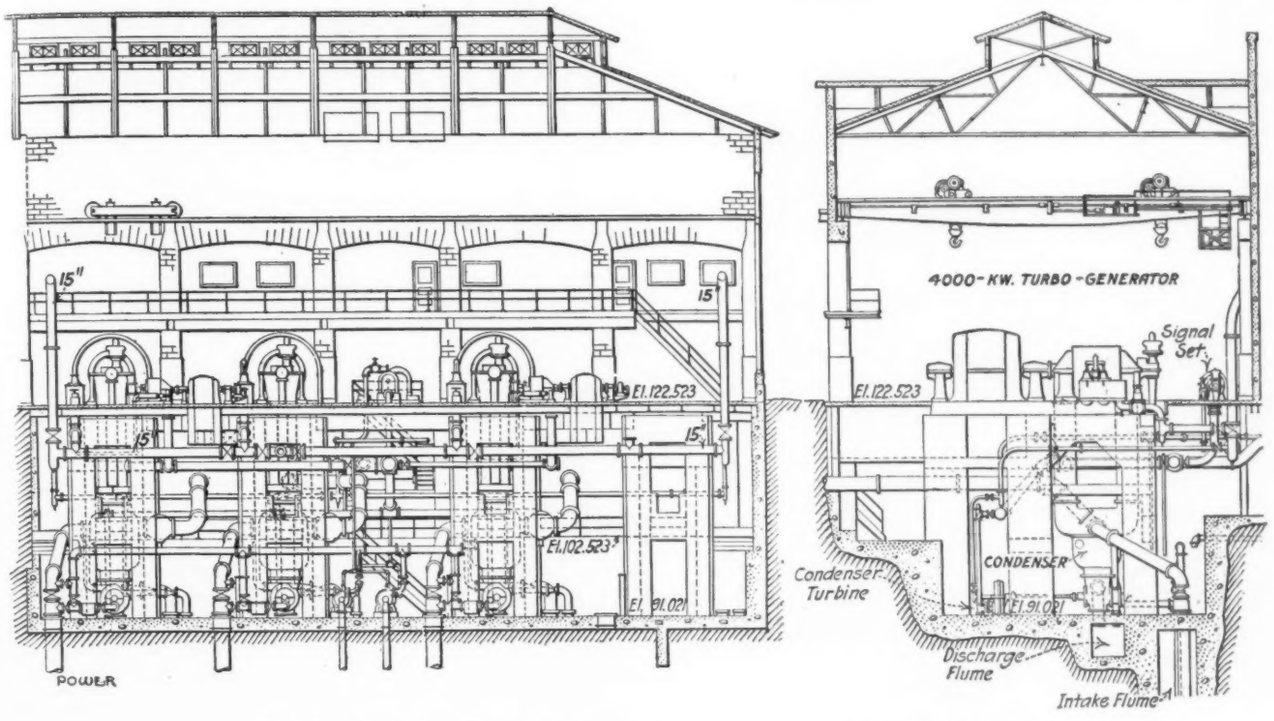


FIG. 2. SIDE AND END ELEVATION OF TURBINE AND CONDENSER ROOMS

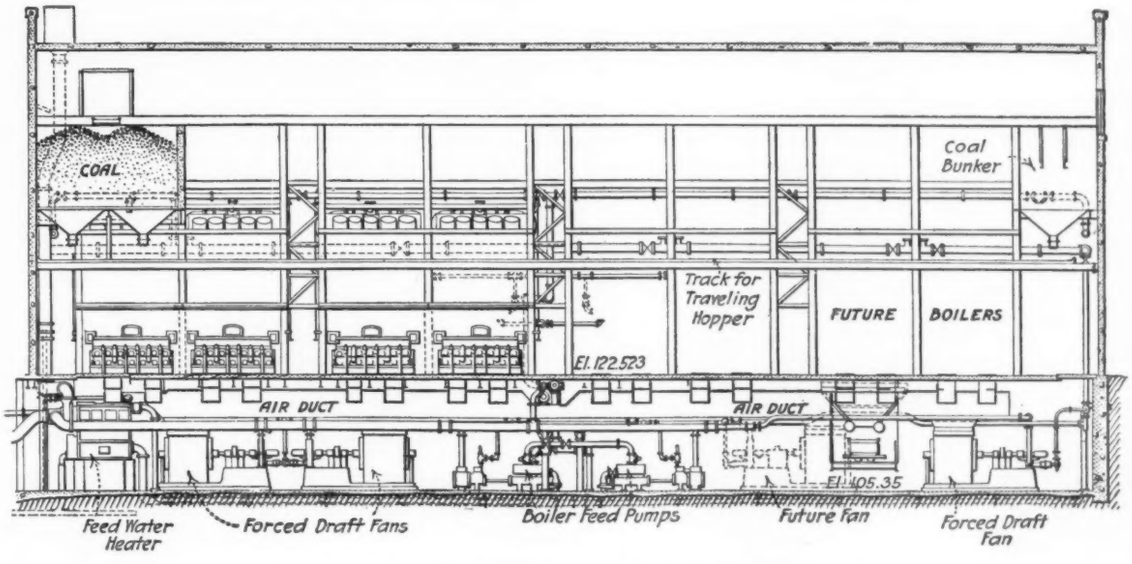


FIG. 3. SIDE ELEVATION OF THE NEW BOILER ROOM

turbine room and but little in the boiler rooms; most of the pipe lines are in the basement.

BOILER ROOMS

In the old boiler room, Fig. 5, there are 14 three-drum water-tube boilers, each having 5200 sq.ft. of heating surface. The furnaces are fitted with mechanical stokers. The boilers are arranged two in a battery, with eight on one side and six on the other side of the boiler room. Each furnace is supplied with induced draft by a single boilers (Fig. 6), each having 6250 sq.ft. of heating surface. The tubes are 14 and 18 ft. in length and 3¼ in. in diameter. These boilers are of the counter-current type, the hottest water meeting the hottest gases and the coldest water meeting the coldest gases. The direct heating surface, or that in contact with the radiant heat of the furnaces, is 12 per cent. of the total heating surface, or 750 sq.ft.

The boilers are equipped with superheaters, which superheat the steam 100 deg. F. Each boiler furnace is fitted

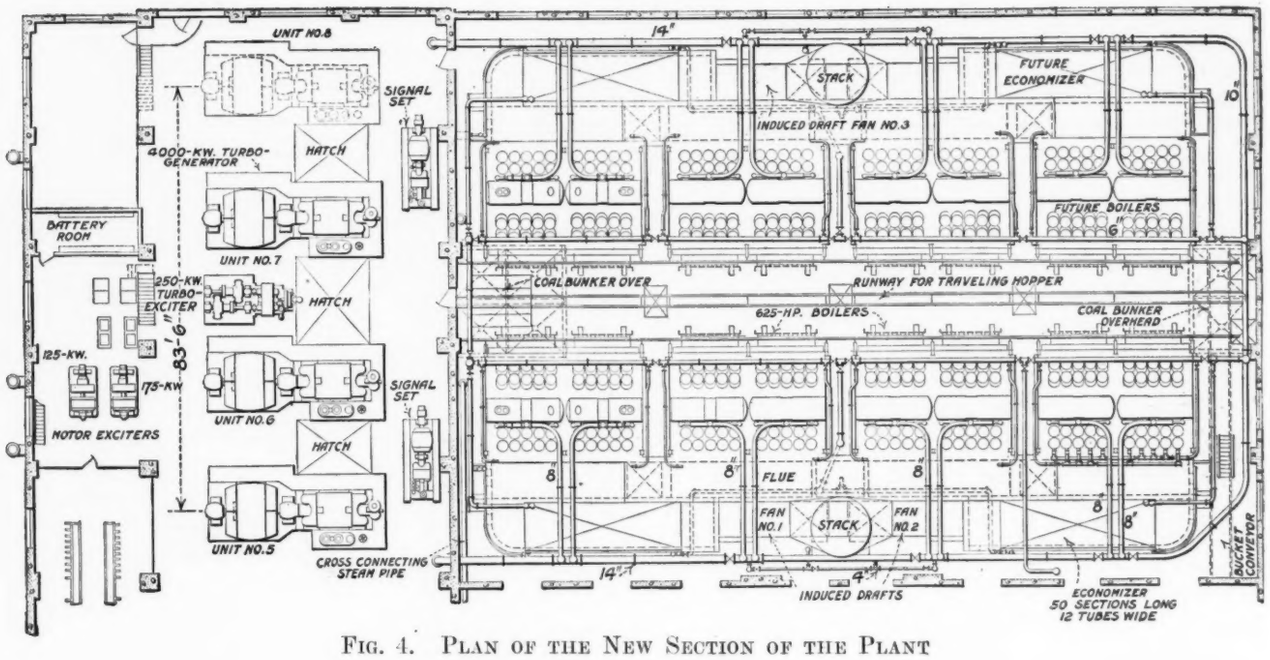


FIG. 4. PLAN OF THE NEW SECTION OF THE PLANT

with a seven-retort underfeed stoker driven by the induced-draft fan turbine. A combination forced- and induced-draft system is used. There are three double-inlet, up-blast, forced-draft, turbine-driven fans (Fig. 7) in the pump room, which is under the firing aisle of the boiler room. Each fan is 42 in. in diameter and delivers 100,000 cu.ft. per min. at 50 deg. F., against a resistance of 5 in. of water. This would require 190 hp. per fan at a fan speed of 510 r.p.m. The turbines run noncondensing at 2040 r.p.m., against a back pressure of about two pounds. Each has sufficient capacity to supply about twenty-five horsepower more than is required by the fan, for the purpose of driving stoker mechanism. Under normal operating conditions but two of the three fans are in operation, and the capacity required of them with the boilers running at 200 per cent. rating will be 95,000 cu.ft. per min. per fan. At this load the maintained resistance is figured to be only 4 in., but 5 is supplied to be on the safe side.

The speed of the fans is governed by the boiler pressure, 200 lb., 100 deg. superheat, acting on a regulating valve which controls the steam supply to the turbines. The difference in speed between the turbine and fan is due to a set of 4 to 1 reduction gears composed of a pair of double-helicoidal gears and flexible couplings, Fig. 8. As the stokers are driven by a series of chain drives, the feeding of the stokers and the speed of the fans are regulated by the steam pressure and operate in unison. The position of the fans is shown in Fig. 3. Space has been provided for a future fan outfit.

At the back of each row of boilers, and between them and the economizers, is a main smoke flue, 6 ft. 9 in. wide and 10 ft. 6 in. high. One flue connects with two economizers, which receive gases from eight boilers. On the opposite side of the boiler room the smoke flue of six boilers connects to a single economizer of the same size as the others.

The induced-draft fans, of which there are two for each row of boilers, are placed between the economizers and the 12½-ft. diameter metal stack. The general arrangement and a plan view of the boiler room are shown in Fig. 4. One of the engine-driven fans is shown in Fig. 9. Each of the four fans is designed to handle 140,000 cu.in. of gas at 500 deg. F., against 1¾-in. suction.

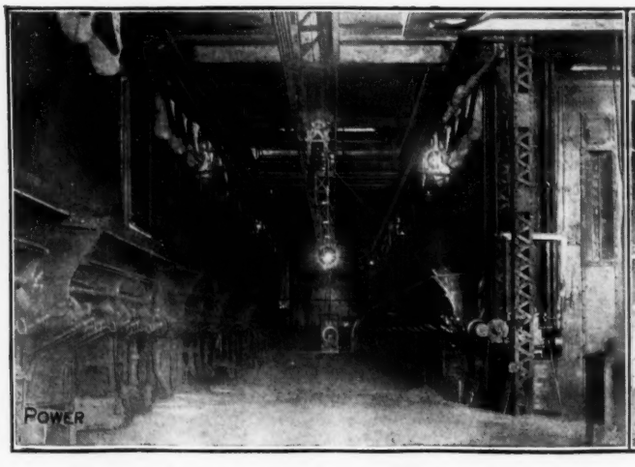


FIG. 5. OLD BOILER ROOM

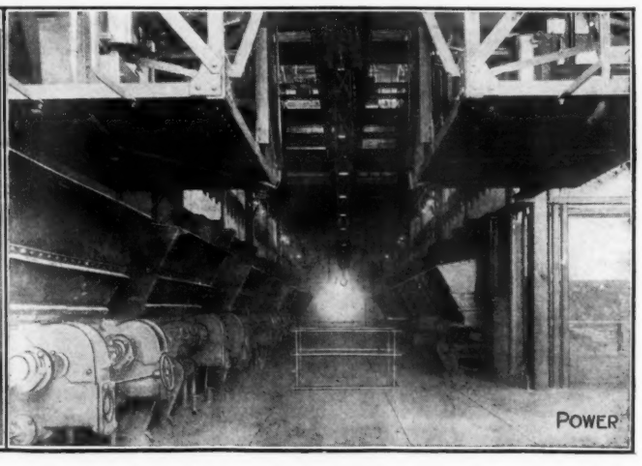


FIG. 6. NEW BOILER ROOM

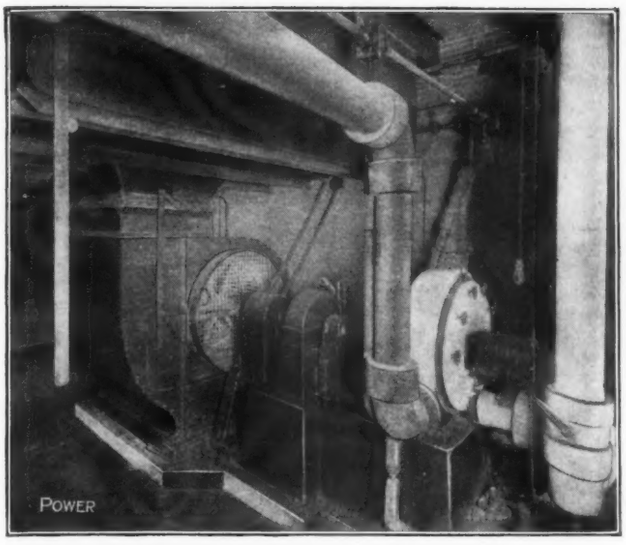


FIG. 7. TURBO-DRIVEN FORCED-DRAFT FAN

The normal volume of air handled is considerably less than that mentioned. The fans are on the ground floor of the boiler room. Their bearings are water-cooled.

As there are three economizers used in connection with the 14 boilers, the average is 8330 sq.ft. of boiler heating surface to one economizer. The boiler pressure being approximately 200 lb., the economizers carry about 50 lb. greater pressure. Each economizer has 624 pipes in 52 sections, each 12 pipes wide. The pipes are 10 ft. long between headers and are arranged in staggered rows. In the other boiler room there are also three economizers of 52 sections, 10 tubes in each.

The damper arrangement is such that if any battery of two boilers be cut out of service, the gases from the others will still go to the economizer. In case it is desirable either or all economizers can be cut out and the furnace gases bypassed to the stack. Although there are two fans for six boilers, on one side of each boiler room space has been reserved for another economizer and two additional boilers.

PUMPS

In both the new and the old boiler plants the pump room is in the boiler-house basement. Figs. 10 and 11 show a view of each. In the old pump room there are three 12&20x12x18-in. duplex pot-valve, boiler-feed pumps which supply the turbine glands with water. In the new pump room there are two boiler-feed pumps of the same size as the others, and two 8x8x18-in. duplex pumps for supplying gland water to the turbines.

FUEL SUPPLY

There are two sources of coal supply—by rail and by water. Barring delays, the fuel is delivered in barges to a wharf, hoisted by a clam-shell bucket and discharged into a coal crusher, from which it is loaded into two 2½-ton cable-drawn cars. These cars are hauled up the single-track runway, Fig. 12, and discharge the coal into the bins at the turbine-room end of the boiler house. At the opposite end of each boiler room is a second bin, supplied from cars which discharge into an underground hopper and crusher from which the coal is elevated to the bins by a bucket conveyor.

In case there is no available coal supply from the railroad, the bunkers can be filled by loading the 5-ton larry car used ordinarily to supply the stokers from the other coal bunkers and discharging its contents into a chute leading to a hopper above the conveyor. Thus, the supply of coal in the bin not reached by cable cars is maintained. An ingenious track arrangement permits of the cable cars passing at a turnout on the runway. This is made possible by the use of outside- and inside-flanged carwheels. A glance at Fig. 13 shows how the cars take the rails. One car has the inside-flanged wheels

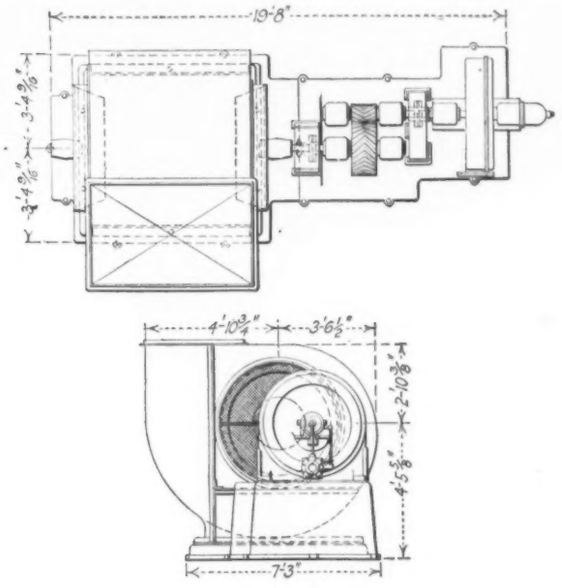


FIG. 8. DIAGRAM OF FAN UNIT

and the other car outside flanges. Fig. 12 shows the cars about to pass at the turnout. This arrangement requires but a single track and reduces the construction cost of the trestle.

From the bins the coal is discharged into the larry scales, where it is weighed and then run along the track

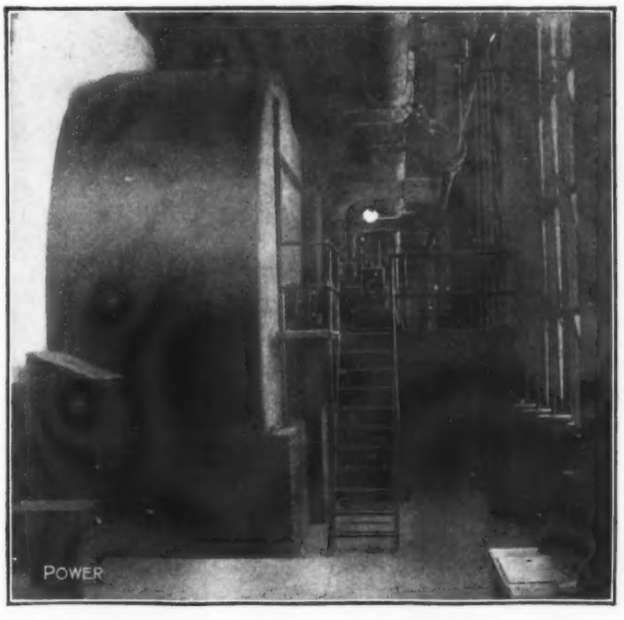


FIG. 9. ENGINE-DRIVEN INDUCED-DRAFT FAN

above the stoker hoppers. Five men handle all the coal consumed in the plant. Two are at the hoisting tower, one above the coal bunkers and one man in both boiler rooms to handle the barney cars.

Ashes from each stoker fall into a brick-lined hopper under which a car is run to receive its load, which is drawn out into the yard by a small storage-battery locomotive and dumped for filling-in purposes.

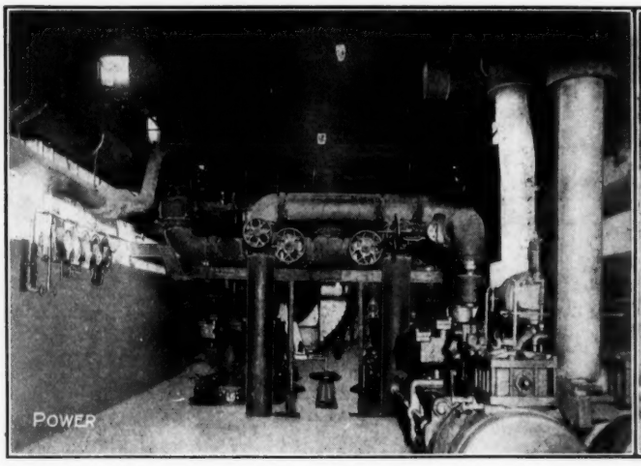


Fig. 10. New Pump Room

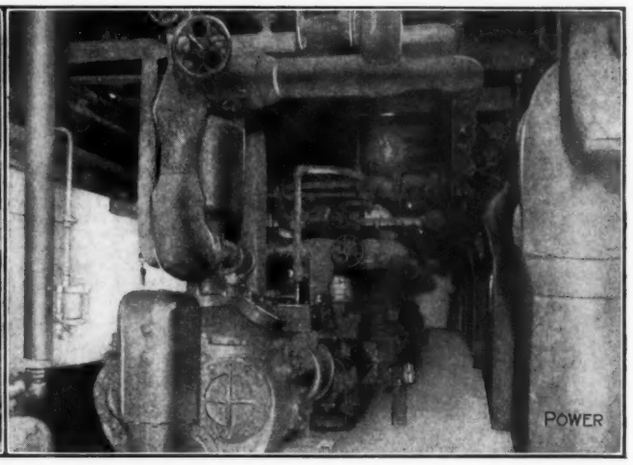


Fig. 11. Old Pump Room

Piping

An end elevation of the new boiler room is shown in Fig. 14, which with Fig. 4 presents the details. Each boiler is connected by an 8-in. branch pipe to the main 10-in. header. The header is constructed on the loop plan and so valved that any two boilers and their section of header may be cut out of service without interfering with any other units. The headers back of the two rows of boilers drop to a 15-in. cross header in the turbine-room basement. From this a 10-in. lead is run to each of the new turbines. This piping is shown in Fig. 2.

The 6-in. auxiliary header has three sources of steam supply. It is also designed on the loop plan, tapping off from each of the 15-in. vertical header pipes and also from the 10-in. end of the main steam loop in the boiler house. The auxiliary steam line supplies the condenser turbines through 3-in. pipes. The exciter turbine receives its steam supply through a 4-in. pipe connecting with that section of the 6-in. header running to the pump room and connecting the main steam line at the loop end. A study of the piping scheme shows its simplicity, although provision has been taken to insure continuity of service.

While the addition to the plant is practically a separate power plant in itself as applied to the steam end, the new boiler room is connected to the old by a 10-in. cross connection, which is connected with the 15-in. cross-feeder in the turbine basement.

The 10,000-hp. feed-water heater for each boiler plant is in the basement and is piped to the boiler feed-water pumps by a 12-in. pipe having a 7-in. branch pipe to each pump, which discharges into a 9-in. main connecting with the economizers. From the economizers the 9-in. feed line forms a loop along the front of the boiler and supplies them through 3½-in. branch lines.

All boiler blowoff pipes are in a tunnel under the main smoke flue. The blowoff main for the economizer is also in this tunnel.

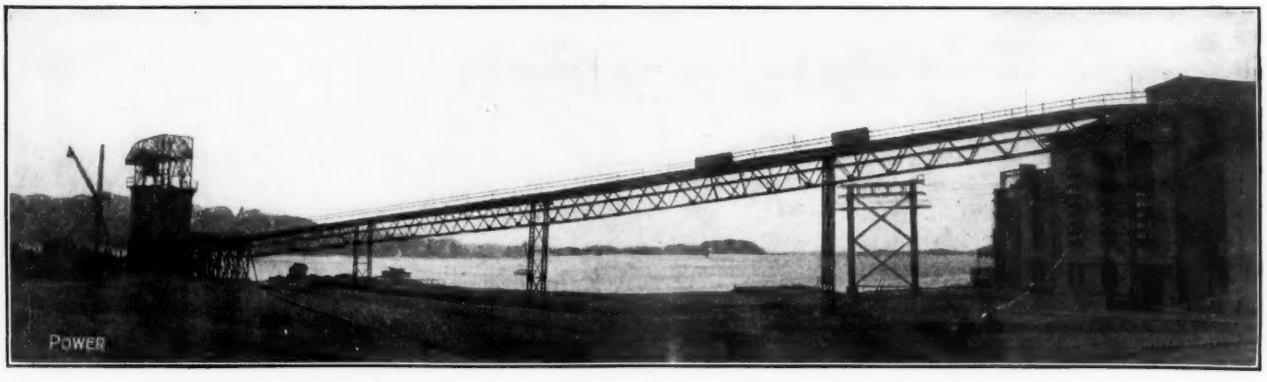


Fig. 12. Single-Track Runway Using Double-Car Service

As in most large power plants, the pipe lines are designated by colors. In the Cos Cob plant the pipe-line color scheme is as follows: White—high-pressure steam lines; red—Holly return system; yellow—auxiliary exhaust and all low-pressure drips; black—boiler-feed lines; blue—all water pipes other than feed and fire pipes; gray—fire protection; dark green—air pipes; light green—crank-case oil piping; pink—cylinder oil piping; brass, no paint—turbine oil piping.

As is now the general practice in modern power plants, all of the electrical-control apparatus is at one side of the turbine room. A gallery runs the length of the building and at one end is the chief engineer's private office, the general office and switchboard room (Fig. 15). On the same level are the remote-control oil switches (Fig. 16). Below, in suitable compartments, are the duplicate busbars. At the back of the station, a general view of which is shown in Fig. 17, is a transformer house in which are six 7200-kv.-a. auto-transformers, which raise the voltage from 11,000 to 22,000 volts, the center point of the transformers being connected to the rails.

Fig. 18 is a diagram of the present system of distribution. Line auto-transformers are arranged along the track and are similarly connected for reducing the voltage to 11,000 for the locomotives. The center terminal of the outdoor transformers is connected to the rails, one terminal to the contact wire and the other to the feeder wire. This arrangement breaks the line into short lengths. Reference to Fig. 18 shows that a train draws its current from the transformers on either side of it. If the train is midway between transformers half of the current will complete its circuit through the rails and ground in one direction, and the other half through the rails and ground in the other. When the train is nearer to one transformer than another it will receive the greater part of its current from the nearest one and the smaller part from the distant transformer. Thus the current supply balances regardless of which transformer the larger amount is taken from.

The changes from the old to the new system were considerable, because the transition had to be made without interfering with the operation of the train service, making necessary many temporary connections and the perfecting of details which would allow of a rapid and easy change-over when the final connections were made.

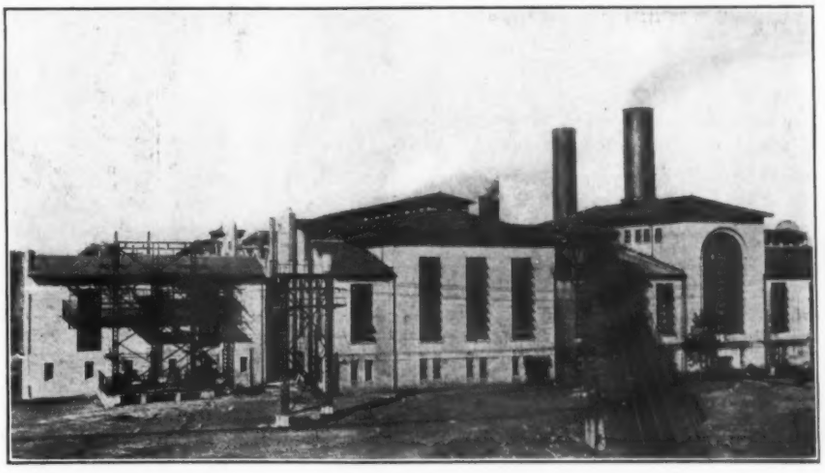


FIG. 13. TRACK AND TURNOUT ARRANGEMENT FOR CABLE-DRAWN CARS

When it is considered that about 350 miles of track is electrified it is seen that it was important that each man along the line should know what to do and when to do it. At some points the changes consisted of merely disconnecting a few wires, and at others many changes were necessary. As the final work was done at night, team

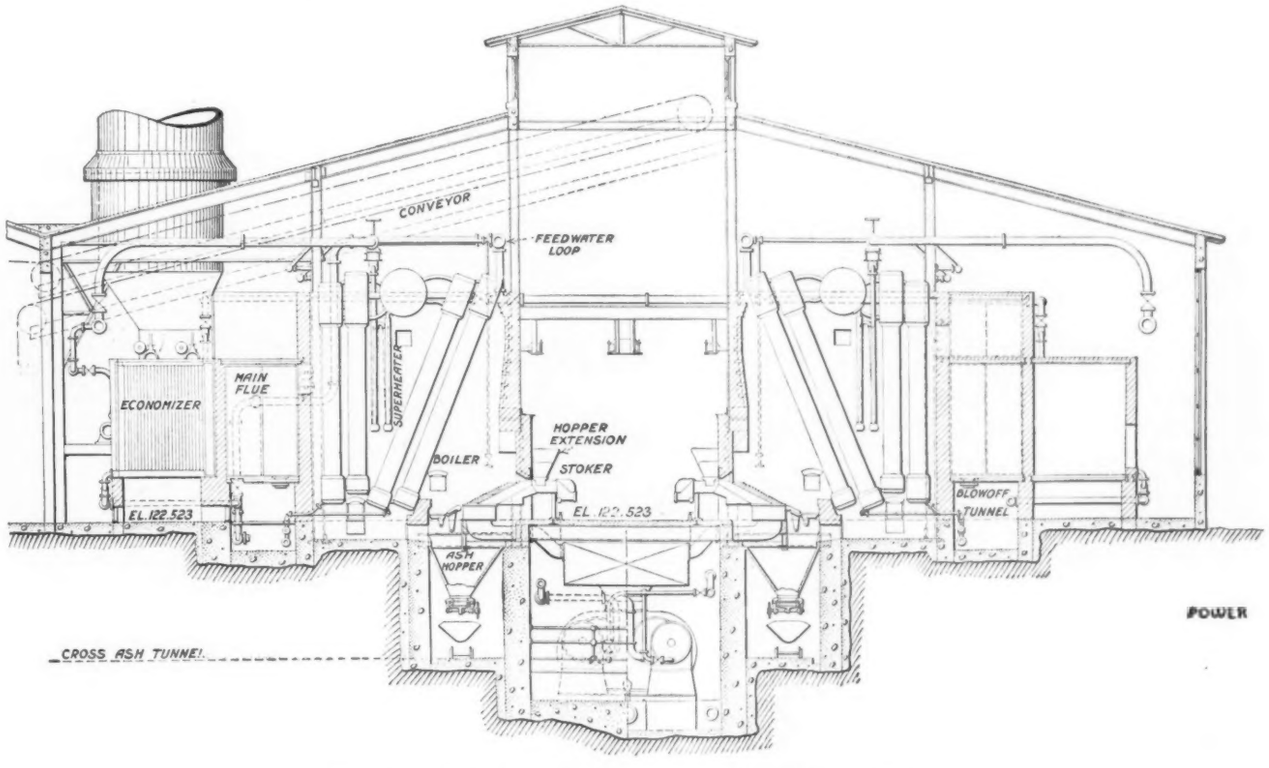


FIG. 14. END ELEVATION OF THE NEW BOILER ROOM

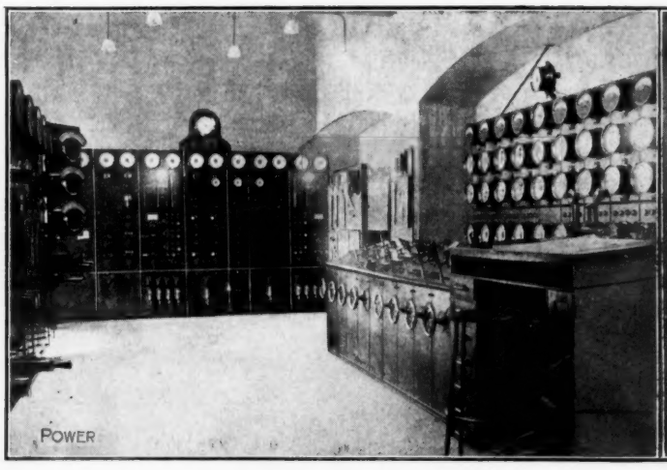


FIG. 15. CONTROL ROOM WITH SWITCH AND BENCH BOARDS

FIG. 16. AISLE BETWEEN REMOTELY CONTROLLED OIL SWITCHES

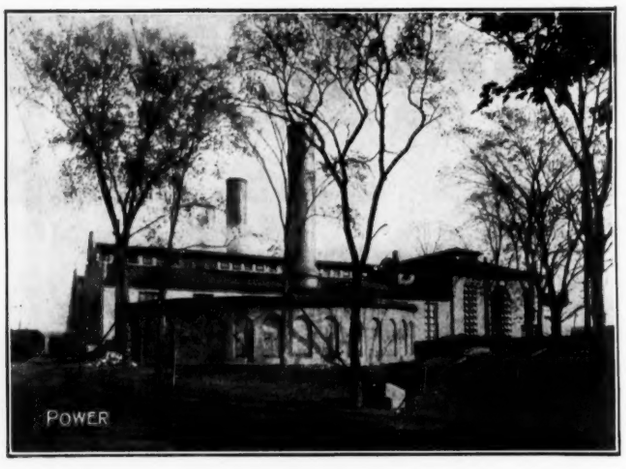


FIG. 17. GENERAL VIEW OF THE STATION

work of the highest order was imperative and a mistake would mean delay.

But four hours, from 2 to 6 a.m., were available for the final change-over. At 2 o'clock the power plant was shut down, and all concerned were notified. Within two minutes the load dispatcher received the first "ready" report. This was quickly followed by others and within 70 minutes from the start the last report was in and all work on 350 miles of track had been finished.

The power-house changes required longer, but at 3:21 a.m. the plant was ready to start up under the new system. At 4:45 a.m. every part of the system was reported ready for service and at 5:25 the first train received current by the new system. At 5:31 the operating department was advised that full normal service might be resumed.

The entire work of addition and reconstruction of both the power plant and lines as herein described was performed by the Engineering Department of the New York, New Haven & Hartford R.R., and the plans for the entire work were prepared by Westinghouse Church Kerr & Co., to whom the author is indebted for line drawings of the power-plant addition.

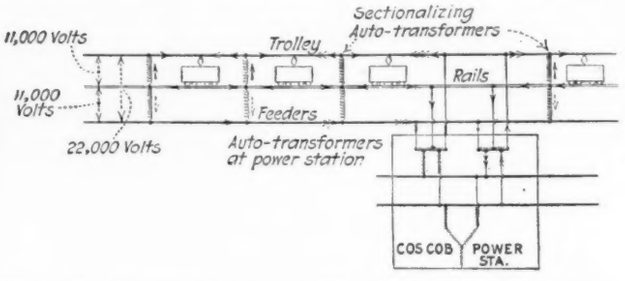


FIG. 18. DIAGRAM OF THE NEW SYSTEM OF ELECTRIFICATION

PRINCIPAL EQUIPMENT OF THE COS COB POWER PLANT ADDITION

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Turbo-generators	Horizontal	5000-kv.-a.	Main units	180 lb. steam, 100 deg. superheat, 1500 r.p.m., 1-phase, 25-cycle, 11,000 volt	Westinghouse Companies
4	Condensers	Leblanc, jet	No. 19	With 5000-kw. turbines	28-28½-in. vacuum	Westinghouse Machine Co.
4	Turbines	Single-stage		Condenser pump drive	180 lb. steam, 100 deg. superheat, 680 r.p.m.	Westinghouse Machine Co.
1	Turbine	Horizontal	125-kw.	Driving exciter generator	180 lb. steam, 100 deg. superheat	De Laval Steam Turbine Co.
2	Generators	Direct-current	125-kw.	Exciting main generators	750 r.p.m., 125 volts	Westinghouse Electric & Mfg. Co.
2	Motors	Induction	190-kw.	Driving exciters	480 r.p.m., 440 volts	Westinghouse Electric & Mfg. Co.
2	Generators	Direct-current	125-kw.	Exciting main generators	480 r.p.m., 125 volts	Westinghouse Electric & Mfg. Co.
2	Turbo-generators	Horizontal	130-kw.	Signal service	3600 r.p.m., 2300 volts, single-phase, 60 cycles	Westinghouse Companies
1	Motor-generator	Direct-connected	500-hp., 450-kv.-a.	Signal service	720 r.p.m., 2300 volts, three-phase, 60 cycles	Westinghouse Electric & Mfg. Co.
14	Boilers	Bigelow-Hornsby	6250 sq.ft. heating surface	Steam generators	180 lb. steam, forced and induced draft	Bigelow Co.
14	Stokers	Taylor	Seven-retort	With main boilers	Driven by forced-draft turbines	American Engineering Co.
14	Superheaters	Foster		With main boilers	100 deg. superheat	Power Specialty Co.
3	Turbines	Single-stage	215-hp.	Driving 42-in. fans	180 lb. steam, variable-speed	De Laval Steam Turbine Co.
3	Fans	Up-blast-multivane	42-in.	Forced-draft	Turbine-driven, with reduction gears	B. F. Sturtevant Co.
3	Engines	Slide-valve		Driving induced-draft fans	180 lb. steam, variable-speed	Skinner Engine Co.
3	Fans	Encased	12-ft. diameter	Induced-draft	Engine-driven, variable-speed	B. F. Sturtevant Co.
3	Economizers	Sturtevant	833 sq.ft. heating surface	With Bigelow boilers	With flue gases	B. F. Sturtevant Co.
2	Pumps	Duplex-pot-valve	12&20x12x18-in.	Boiler feed	Automatically controlled	Warren Steam Pump Co.
2	Pumps	Duplex	8x8x18-in.	Water to gland on turbines	Constant-speed, automatically controlled	Wilson-Snyder Mfg. Co.

Maintaining High Insulation Resistance

By H. M. McLellan

Where electrical machinery is subjected to fumes, as sometimes when located in gas-engine stations or near chemical plants, it is necessary that special precautions be taken to insure the insulation resistance being maintained at a high value. Deposits of carbon and copper dust, dirt, or chemicals will often be found on the windings of apparatus operated under these conditions. These are conductors and, consequently, lower the insulation resistance over the surfaces, making the current likely to creep from exposed live metal parts to the core, and so cause a burn-out.

Ordinarily, the deposit appears not to attack the insulation, and the only thing necessary to prevent trouble is to clean the machine at frequent intervals, testing its condition by readings of insulation resistance. In order that the surfaces may be readily cleaned, they should first have a good smooth finish, such as is obtained from several coats of varnish. Most machines have this finish when sent from the works, but under certain conditions it may become rough, and then it is necessary that the windings be revarnished.

The insulation resistance is most readily measured with a megger, or if this is not available, a high-resistance voltmeter may be used in the following manner:

First, read the voltage across the line; then connect the voltmeter in series with the insulation resistance (between a commutator bar and the shaft) and read the volts again.

If R is the resistance of the voltmeter, V the reading of the voltmeter across the line, and V_1 the reading in series with the insulation, then the resistance of the insulation is

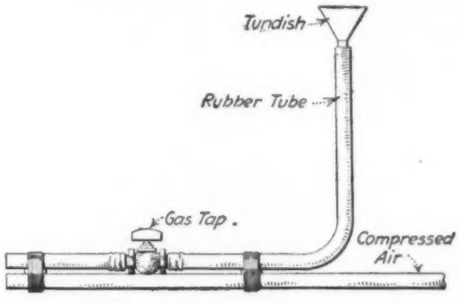
$$R_1 = \frac{R\,(V - V_1)}{V_1}$$

The resistance of the voltmeter is usually marked on the back of the instrument or on the carrying case; if not, it may be obtained from the makers.

When the insulation resistance of a machine shows a value of less than 250,000 ohms, this indicates that the windings are covered with dirt, and steps should be taken at once to clean them thoroughly. The best method is to thoroughly blow out the machine with compressed air. After this measure the insulation resistance. If it has reached a high value, say not less than 2 megohms, it indicates that the insulation surfaces are in good condition, but if little improvement is noted, thoroughly wipe all parts of the machine with a soft cloth and take insulation readings at frequent intervals during this operation, with a view to determining where the greatest improvement is effected. When the resistance reaches a good value, say not less than 2 megohms, the windings should be thoroughly sprayed with a good air-drying varnish. It is useless to spray the machine while covered with dirt, with the insulation resistance low; in fact, if this is done, it will be impossible to remove the dirt after it is coated with varnish, and the machine may have to be completely reinsulated.

Where compressed air is available, the best method for applying the varnish is as follows: Procure a length of ½-in. rubber tubing, say about 3 yd., and near one end fit an ordinary gas tap, as shown in the sketch, leaving about 3 in. of pipe from the tap. In the other end fit a tundish, then tie the paint tube on top of the air pipe. Varnish is poured into the tundish and will flow down the pipe, the supply being regulated by the gas tap. As it tries to pass the end of the air pipe it will be blown into a fine spray, which can be directed to the desired spot. The machine should stand for at least twelve hours after varnishing to allow for thorough drying.

In general it is desirable to give the machine more than one coat of varnish, and where the surface of the insulation is very rough it may be advisable to apply as many as four coats. These may be applied one after the other, allowing sufficient time between applications for the machine to dry, or they may be applied at convenient intervals. In the latter case, the machine must, of course, be thoroughly cleaned before each application. The point to keep in mind is that if the machine is to be easily cleaned there must be a good smooth finish on all surfaces over which the current is likely to creep, and this surface must be cleaned at frequent intervals.



Device for Applying Varnish

In dealing with direct-current apparatus, especial attention must be given to deposit forming on the under side of the armature coils between the commutator necks and the core, and on the mica between the commutator necks and the V-ring. Consequently, in cleaning such machines, these parts and the insides of the machines behind the commutator should receive particular care. A soft tape should be threaded under the armature coils, one at a time, and worked back and forth until all deposit is removed, especially from the corners where each coil leaves its slot.

Alternating-current apparatus is in general not likely to show a decrease in insulation resistance after running, as in alternating-current machines there are seldom any exposed live surfaces except collector rings, brush gear, etc., but the machines generally, and these parts especially, should be carefully cleaned at frequent intervals.

A New Canadian Periodical—"Mine, Quarry and Derrick" is the name of a new fortnightly magazine "devoted to the development of the mineral resources of Western Canada." The first issue made its appearance under date of Feb. 3, 1915, and it is promised by the publishers, Laurence & William, of Calgary, Alberta, to reappear "every second Wednesday." The staff consists of J. C. Murray, editor; W. C. McGinnis, associate editor; R. W. Coulthard, contributing editor, and L. S. Kempher, manager. In the salutatory the intentions are declared to be to give real expression to the needs of the great Canadian West; to discuss the technical and other problems to be met; to correct errors and misconceptions, and, above all, to give the investing public the truth as to present conditions, all as relating to the fields of oil production, metal mining, coal mining, quarrying and the manufacture of cement and clay products.

Plate Valves for High-Speed Air Compressors

By G. J. MacFadden

SYNOPSIS—Points out the advantages of the plate valve and explains the construction and operation of several of the most widely used makes.

By the use of plate valves, a much higher piston or rotative speed is possible. Heretofore, the speed of air compressors has been limited by the air valves, as abnormal wear and breakage of valves resulted when the piston speed exceeded 500 ft. per min., caused by the excessive weight and high lift. The mechanically operated Corliss inlet valves have the disadvantage of semirotating surfaces which require positive lubrication and are liable to stick and cut. A complicated valve-gear is also employed, which requires adjustment at frequent intervals.

One of the principal advantages of plate valves is increased efficiency, due to the light weight of the valve proper and light initial tension of the valve springs, allowing the air in and out of the cylinder with small power consumption by the valves. With a light valve and low

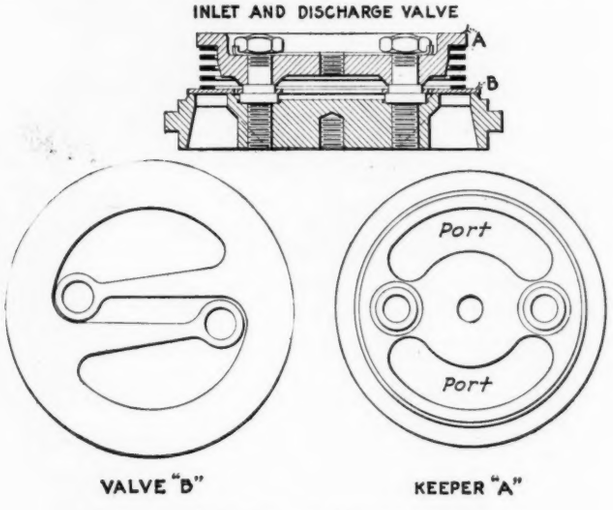


FIG. 1. THE BORSIG (GERMAN) VALVE

spring tension the minimum pressure is required to keep the valve open throughout that portion of the stroke in which it is operating. Another advantage is the low lift which, combined with lightness, reduces the momentum attained on opening, insuring quiet operation and little necessity of cushioning mechanism. The air is admitted to the cylinder in a constant stream and at lower temperature and higher pressure than where the ordinary chattering high-lift poppet valves are used. The valves are silent in operation up to the highest speed, which demonstrates the absence of hammering and fluttering, and reduces wear of the valve and the valve seat. The cost of repairs with the standard makes of plate valves is small.

The higher safe speed of compressors using plate valves means a reduced cost of installation, not only of the compressor unit, but of the building and foundation, since a compressor for a stated capacity, equipped with plate valves and operating at high speed, requires approximately two-thirds the floor space taken up by a slow-speed compressor equipped with the old-style poppet valves. In the case of motor-driven units high speeds mean the additional advantage of smaller and less expensive motors.

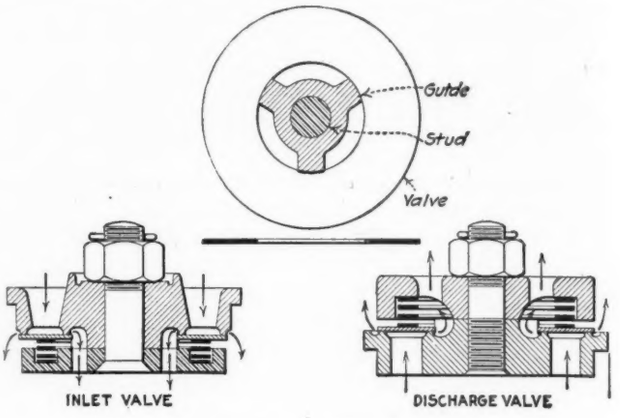


FIG. 2. ANOTHER GERMAN VALVE

To sum up, the principal advantages of the use of plate valves are as follows:

1. Improved mechanical and volumetric efficiency over the old-style poppet valve.
2. Minimum wear; cost of repairs reduced to a negligible amount.
3. The valve requires no lubrication.
4. Silent operation at the highest piston speeds.

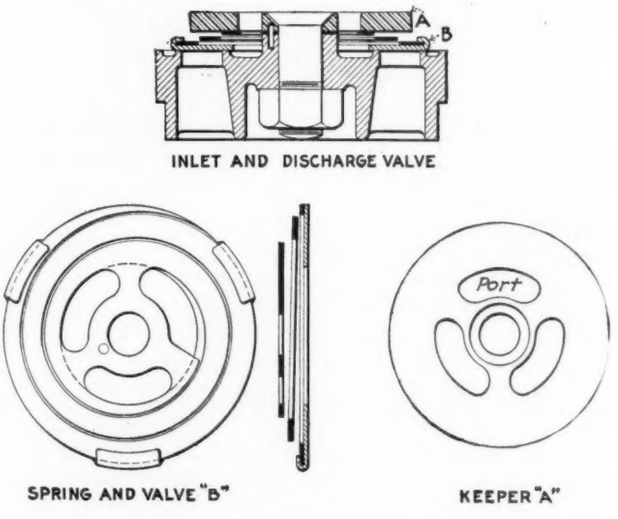


FIG. 3. MESTA MACHINE CO.'S PLATE VALVE

5. The air end is simplified, owing to the elimination of all complicated valve-operating mechanism.
6. Dependable and efficient at high speeds.
7. Floor space and cost of installation reduced on account of greater capacity of smaller units due to high speed.
8. Continuous operation under severe conditions.

Prominent American builders of large and medium-sized compressors have adopted the plate valve for use in

their compressors only within the last two or three years. Conditions were ripe for the innovation, because of keen competition by foreign manufacturers, who have employed the plate valve with success for some years.

In the following description of plate valves only those of standard Continental and American construction will be discussed. They may, however, be taken as represen-

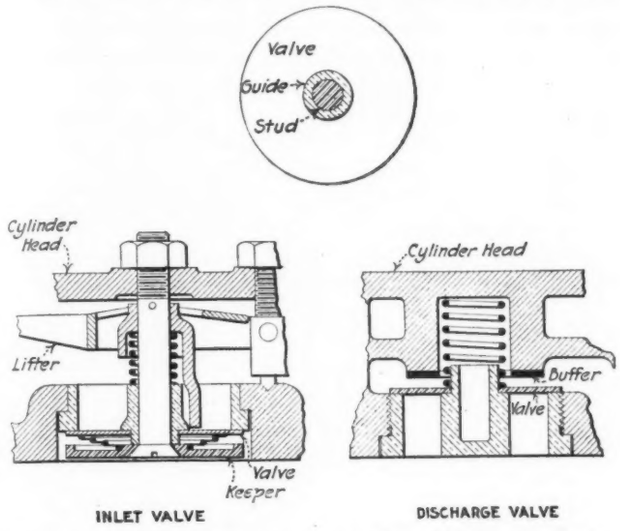


FIG. 4. VALVE USED BY THE CURTIS MANUFACTURING CO.

tative for the whole development along this line, since with few exceptions, they follow closely the original German design.

Fig. 1 shows a section elevation and plan view of the Borsig valve, manufactured by A. Borsig, Berlin. The valve consists essentially of a thin sheet-metal disk of light weight, and is made to form two spiral arms

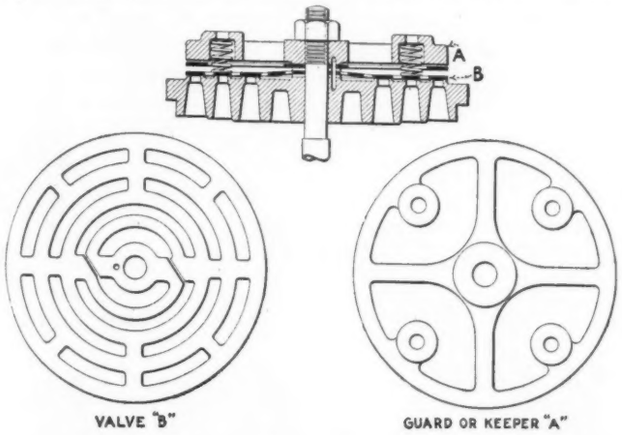


FIG. 5. THE ROGLER PLATE VALVE (INGERSOLL-RAND CO.)

secured at the center of the valve by two studs, one in each arm; a small movement of the valve arms is allowed on each stud, depending on the lift of the valve. Above the valve disk a keeper or stop is provided, in which a large helical spring is seated. This spring serves to load the valve and press it firmly on its seat. The point of support of the arms is located in the center of the valve lift so that the disk is bent upward when the valve is opened, and owing to the small mass of the valve proper, its inertia is negligible. The construction of this valve is such that it may be used for either discharge or inlet.

Fig. 2 shows a plate valve used by the *Zwichauer Maschinenfabrik Aktiengesellshaft Zwichau,* Saxony, one of the large compressor builders of Germany. The valve complete consists essentially of six pieces. The seat is a circular iron casting having either one or two ports. The keeper is a simple iron casting having ports cored through to allow the passage of air from the inner edge of the valve. The valve spring is of the helical type of rectangular section, allowing a much more compact arrangement where fully compressed than a spring of circular section. The valve keeper is provided with a recess of sufficient depth to accommodate the spring when the valve attains its greatest lift. The valve proper consists of a thin disk stamped from sheet steel, being centrally guided by projections on the valve seat. The valves are not interchangeable for inlet or discharge.

Fig. 3 shows the construction of the Mesta automatic plate valve, manufactured by the Mesta Machine Co., of Pittsburgh, Penn., under the Iversen patent. The valve

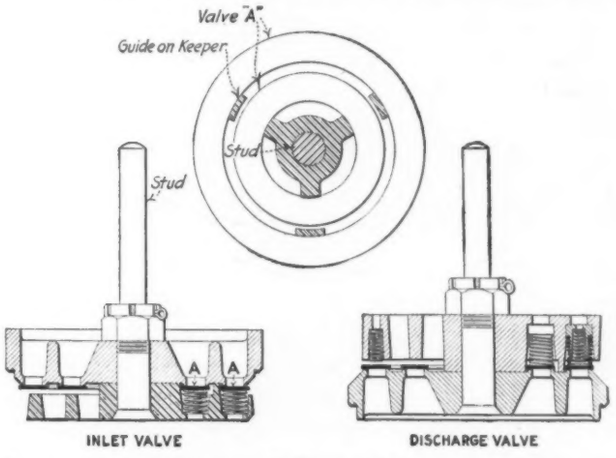


FIG. 6. THE "SIMPLATE" VALVE (CHICAGO PNEUMATIC TOOL CO.)

proper consists of a light, thin, annular steel plate, guided by a flat volute spring. The spring is permanently fastened to the valve plate by prongs or clips bent over the outside edge of the spring. The valve lifts parallel to the seat and employs no guiding surfaces or guide pins. The valve seat is a circular iron casting having one or more annular ports. The valve keeper consists of a thin plate of steel, with punched ports or recesses provided to allow the free passage of air from the inside of the valve.

Fig. 4 shows the details of the inlet and discharge valves made by the Curtis Manufacturing Co., of St. Louis, Mo. The valve proper is a thin disk stamped from sheet steel. The valve seat is of phosphor-bronze, having independent ports or cored passages for the flow of air. The inlet and discharge valves are of independent design, but are not interchangeable. The inlet-valve keeper is of steel and provided with a suitable recess to accommodate the valve spring. The valve complete is held in a pocket in the cylinder head by a flat-head stud. The discharge valve proper is screwed into a tapped hole in the air-cylinder head. The spring is held in a pocket and a seat is provided in the cylinder head to act as the valve keeper or buffer. These valves, due to their thin construction, permit the passage of air around the outside edge only, as the valve is guided on a circular projection at the center of the valve seat.

Fig. 5 shows a section of the Rogler plate valve, built by

the Ingersoll-Rand Co., and which is essentially of German design. The valve proper is made of special steel, treated, tempered and ground. Narrow, integral spring arms, ground to about half the thickness of the valve proper to give them elasticity, are located at the middle portion of the valve. These arms act as a connecting means between the fixed and moving parts of the valve, holding the latter in one position and seating it always in the same place on the valve seat. The valve seat is of special material, cast with circular ports. The keeper is a special casting provided with four spring pockets to accommodate the four main valve springs which hold the valve on its seat against the slight tension of the integral valve arms. A cushion plate, fixed at the center only and having a certain amount of elasticity, is employed to cushion the valve at the point of full opening. It will be noted by referring to the cross-section that a washer is placed between the valve proper and the valve seat and between the cushion plate and the valve proper. All parts are kept from turning by a dowel pin and are clamped together by a through bolt.

Fig. 6 shows the "Simplate" valve, designed and built by the Chicago Pneumatic Tool Co. The seat is of special material cast with one or more circular ports, depending upon the size of the valve. The valve proper in the one-ported valve consists of a thin plate, or ring, stamped from sheet steel, heat treated and tempered, then ground to present a true surface on the seat. The multi-ported valves of larger size have two or three distinct and separate valve disks, operating independently of each other. These disks are similar to the one used in the one-ported valve, as described above. The valve keeper on the inlet valve is of special cast steel with suitable ports arranged to allow the flow of air from the inner valve disks. The discharge-valve keeper is of cast iron, provided with ports similar to the inlet-valve keeper. Both inlet- and discharge-valve keepers have drilled recesses for the accommodation of the valve springs. Plain, small, helical springs of light tension are employed on the inlet valve, while on the discharge valve, springs of slightly greater tension, together with buffer or cushion springs, are used. All springs are galvanized to resist the corroding action of the moisture in the air. Valve seat and keeper are held together, in the case of both inlet and discharge valves, by a centrally located stud and castle nut, as shown.

Steam Costs in 6600-Hp. Boiler Plant

By Frank G. Philo

SYNOPSIS—Interesting cost data of a boiler plant for a large manufacturing establishment.

The value of steam-cost data depends primarily on the accuracy with which the coal and steam are measured and the care with which the labor and all operating records are kept. This being the case, it will probably not be amiss to go into detail as to the methods used in obtaining the following data.

Coal Weighing and Analysis

The fuel burned is a mixture of No. 3 buckwheat with about 10 per cent. soft coal. To obtain the total weight of coal consumed as well as the proportions of the two coals mixed, the following method is used. The hard coal is weighed as received in the railroad cars, on carefully tested track scales which check within 10 lb. with standard weights. The hard coal is then dumped into a machine which mixes it thoroughly with the crushed soft coal. The mixture is carried overhead by a conveyor and dumped into cable cars of 2-ton capacity each. The weight of the mixed coal is obtained by weighing the small cars on a second set of scales at this point. From the hard-coal weights and the weight of the mixture the total weight used, as well as the percentage of each kind of coal in the mixture, is obtained. The automatic mixer is so designed that it can be adjusted to give any proportions of the two coals desired. The cost of the mixture is increased about one cent for each 1 per cent. of soft coal added. The function of the soft coal is to act as a binder for the small anthracite and to supply the necessary volatile matter which assists materially in starting a fire after cleaning periods. The soft coal also helps to burn out the fires more thoroughly before dumping.

Analyses of coal and cinders are made daily. The number of cars of coal which the sample represents, together with the road and car numbers, are entered on the laboratory sheet. The average analysis for the month is found by multiplying each analysis by the number of cars it represents and dividing the sum of these totals by the total number of cars used during the month.

The average analyses of the coal fired during the first six months of 1914 were as follows:

	Jan.	Feb.	Mar.	Apr.	May	June
Moisture	9.27	9.05	8.72	8.44	8.01	7.91
Ash (dry basis)	24.15	23.84	24.09	20.28	19.72	24.22
B.t.u. (dry basis)	11,070	11,140	11,150	11,563	11,674	11,051
B.t.u. (as fired)	10,043	10,132	10,178	10,587	10,739	10,177
Combustible (as fired)	68.82	69.27	69.29	72.99	73.85	69.79

Feed-Water Measurement

Feed water is measured by two venturi meters of 3000 and 4600 cu.ft. per hour capacity, respectively. The adjustments of these meters are checked weekly and once a month weight checks are run by passing water at working temperature and pressure through the meters into carefully weighed tank cars, which are run alongside the boiler house. These tank cars have a capacity of about 60,000 lb. of water. All tests are run for at least 30 min., so the personal errors in starting and stopping are small. The errors of the meters were found to be practically constant for any given rate of flow. The average error over the working range covered in practice was found and a correction applied to the daily meter readings. The average error of the meters was found to be about ¾ per cent. low.

All water blown from boilers and economizers, as well as all water discharged in emptying boilers and economizers for repairs, is subtracted from the water registered by the meters. This water amounts to from 1 to 2 per cent. of the total water passed through the meters during the month. The blow-down pipes from each boiler are provided with plug cocks and valves. The blow-down headers from each battery of boilers have gate valves. All blow-down valves and lines are inspected daily to insure against loss of water from boilers by leakage.

Records of Operation

Daily reports are made showing the weight of water evaporated, the average rating developed by the boilers, feed-water temperatures, steam pressure, economizer inlet and outlet water and flue-gas temperatures, flue-gas analyses, coal and cinder analyses and all useful information regarding the operation of the boiler house.

All materials and supplies are kept in a main storeroom and can be obtained only upon presentation of a signed requisition from the foreman in charge. All labor and materials used by other departments for repairs and maintenance of the boiler house are charged against the boiler house at the end of each month. Thus the cost of labor and material furnished by the pipe, electric, machine and carpenter shops for work done in the boiler house is always obtainable. In reporting materials used all supplies amounting to $20 or over are itemized. Time slips for all employees of the boiler house are filled out by the foremen and are sent to the time keeper's office every day.

Load Factor

The load factor of this plant is very high as the plant is run at full load 24 hr. per day, and about 26 days per month. During the shutdown periods about one-quarter of the total rated boiler capacity is in service.

LOAD ON BOILERS

	Jan.	Feb.	Mar.	Apr.	May	June
Average b.hp. per hr. (operating hr.)	7698	8070	7094	6341	6260	6151
Average b.hp. per hr. (total hr.)	7501	7781	6357	5764	5878	5626
Average load factor (operating hr.)	116.6	122.3	107.5	96.1	94.9	93.2
Average load factor (total hr.)	113.7	117.9	96.3	87.3	89.1	85.2

Total rated b.hp. of plant, 6600.

Average operating boiler horsepower = average boiler horsepower developed per hour while the plant is in operation.

Total average boiler horsepower = average boiler horsepower developed during total hours during the month.

Operating load factor = load factor based on operating boiler horsepower =

$$\frac{\textit{Operating boiler horsepower} \times 100}{6600*}$$

Total load factor = load factor based on total average boiler horsepower =

$$\frac{\textit{Total average boiler horsepower} \times 100}{6600}$$

OPERATING COST OF EVAPORATING 1000 LB. WATER FROM AND AT 212 DEG. F., CENTS

	Jan.	Feb.	Mar.	Apr.	May	June
Coal and freight	10.64	10.38	10.76	9.62	9.82	9.67
Labor	2.60	2.56	2.81	2.89	2.99	3.12
Total	13.24	12.94	13.57	12.51	12.81	12.79
Operating cost per boiler hp.-hr., cents	0.46	0.45	0.47	0.43	0.44	0.44

*Rated capacity of plant.

OPERATING COSTS AS PER CENT. OF TOTAL OPERATING COSTS

	Jan.	Feb.	Mar.	Apr.	May	June
Coal and freight	80.4	80.2	79.3	77.0	76.7	77.2
Labor	19.6	19.8	20.7	23.0	23.3	22.8

	Jan.	Feb.	Mar.	Apr.	May	June
Tons coal used	12,331	11,145	10,450	8,392	8,865	8,136
Cost per 2000 lb. delivered	$1.66	$1.68	$1.68	$1.64	$1.67	$1.66
Lb. coal per boiler hp.-hr.	4.419	4.263	4.419	4.044	4.054	4.017
B.t.u. per lb. (as received)	10,043	10,132	10,178	10,587	10,739	10,177
Efficiency (boiler, economizer and furnace)	75.5	77.6	74.4	78.3	76.9	81.1
Efficiency (boiler and furnace)	69.4	71.2	69.0	72.6	71.4	74.2

Efficiency figures are based on the total coal used during the month, including that used for starting and banking fires, etc. The total water evaporated is checked against the total coal fired. The gain in efficiency due to the economizers is figured from the rise in the feed-water temperature through the economizers.

OPERATING LABOR COSTS PER TON OF COAL FIRED, CENTS

	Jan.	Feb.	Mar.	Apr.	May	June
Handling coal	4.40	4.67	4.90	4.39	4.44	4.78
Firing coal	21.25	21.84	21.19	24.08	24.70	26.01
Removing ashes	3.26	3.28	3.38	4.02	4.24	4.46
General	11.63	11.64	14.44	16.59	17.42	18.26
Total	40.54	41.43	43.91	49.08	50.80	53.51

INDIVIDUAL COSTS AS PER CENT. OF TOTAL COSTS

	Jan.	Feb.	Mar.	Apr.	May	June
Coal and freight	75.9	75.0	75.2	71.4	69.6	70.1
Operating labor	18.5	18.5	19.7	21.3	21.2	22.6
Maintenance labor	1.1	0.7	0.9	1.6	1.1	1.2
Maintenance material	4.5	5.8	4.2	5.7	8.1	6.1

TOTAL COSTS OF COAL, MATERIAL AND LABOR, DOLLARS

	Jan.	Feb.	Mar.	Apr.	May	June
Coal and freight	20,469.46	18,723.60	17,556.00	13,762.88	14,804.55	13,505.76
Operating labor	4,998.98	4,617.37	4,588.59	4,118.79	4,503.42	4,353.57
Maintenance labor	298.63	171.59	213.89	307.28	238.90	238.40
Material	1,204.68	1,437.33	972.49	1,100.50	1,725.73	1,179.32
	26,971.75	24,949.89	23,330.97	19,289.45	21,272.60	19,277.05

DIVISION OF LABOR, BOILER ROOM

	6 a.m.-6 p.m., Day Shift	6 p.m.-6 a.m., Night Shift
Foremen	1—12 hr., $3.25	1—12 hr., $3.25
Water tenders	1—12 hr., $2.75	1—12 hr., $2.75
Ash men	3—12 hr., $2.16	3—12 hr., $2.16
Repair men	11—10 hr., $2.16	1—12 hr., $2.16
Firemen	16—12 hr., $2.75	16—12 hr., $2.75
Coal handlers	7—12 hr., $2.16	
Chief engineer	1— 8 hr., salary	
Efficiency engineer	1— 8 hr., salary	
	41 men	22 men
	Total 63 men	

The boiler equipment consists of fourteen 300-hp. B. & W. boilers and six 400-hp. Edgar water-tube boilers. All boilers are equipped with Green economizers. One foot of economizer surface is provided for each two feet of boiler-heating surface served. All boilers are hand-fired and are equipped with Grieve grates and forced draft produced by a 125-hp. Green fan. The grates have about 8 per cent. air space. The ratio of grate surface to heating surface is 1 to 30. The ash hoppers are of cast iron lined with brick. Ashes are dumped into small cars of one-ton capacity each and are pulled up an incline by a steel cable and dumped into the railroad cars. Coal is handled and delivered to the bunkers by the Mead-Morrison system of cable cars.

Foreign-Built Vessels Admitted to American Registry—Under the act of Congress of Aug. 18, 1914, the foreign-built vessels admitted to American registry up to Feb. 19, 1915, have numbered 129, with 468,509 gross tons, or 303,284 net tons.

The Horsepower Constant is the number of horsepower per pound of mean effective pressure developed by an engine when running at its normal speed. It will be different for different speeds. Knowing the constant, one need only multiply the mean effective pressure (obtained from an indicator diagram) by this constant to know what indicated horsepower the engine is developing. Evidently, by the definition, the horsepower constant is all of the "PLAN" formula except the P.

Testing Small Centrifugal Pumps

By M. R. Blish

SYNOPSIS—Simple directions for making capacity tests of centrifugal pumps.

Although the methods and apparatus to be described are particularly adapted to testing small pumps, they apply with limitations to pumps of large capacity.

Apparatus

The apparatus for measuring the quantity of water delivered by the pump is most important. Where available, weighing tanks will prove most satisfactory for this purpose. Usually, they are arranged side by side, and in between the two a hopper is so placed that the water may be turned from one into the other without interrupting the flow.

Each weighing tank should be of such capacity that it

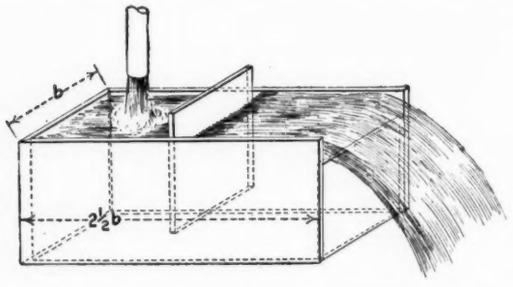


Fig. 1. Partition to Obtain Uniform Flow

will accommodate as much water as will flow in at least two minutes, and have a quick-acting delivery valve of such size that the water can be let out of the tank in one-half the time required to fill it. This will then give time for closing the valve for the reception of the next charge of water and for caring for any unseen delays that may occur while the other tank is being filled. A satisfactory valve for these tanks is a large gate valve in the floor of the tank, operated by a steam or air cylinder on the outside and held to its seat by the weight of the water. This form of valve may be easily opened or closed and the controlling valves placed within easy reach of the man operating the scales. The scale beams should be so arranged that they may be read from the same platform.

Another form of apparatus used to measure the quantity of water is a single large tank fitted with a weir, as in Fig. 1. The capacity of the tank should equal about five minutes' discharge of the pump. It can be made of steel (or wood lined with sheet zinc) and the plan dimensions such that the length is two-and-a-half times the breadth. The weir is placed in the end, not along the side of the tank, and should extend the width of the tank to avoid end contractions* of the water passing over the weir. A partition running parallel with the weir and extending from the top to within 2 ft. of the bottom divides the tank into two compartments. The water should come into the tank on the side of the partition opposite the weir. This arrangement will prevent a serious "velocity of approach" of the water to the weir. If the tank is of wood, it will be necessary to provide a strip of ¼-in. or $\frac{3}{16}$-in. iron for the weir, which may be either set into the wood or screwed to the inside of the tank. The sharper the edge of the weir, the better the results that will be obtained.

Still another form of apparatus for measuring the delivery of the pump consists of a large tank of rectangular plan, from one end of which a wooden trough extends, as in Fig. 2. This trough is inclined at an angle not to exceed ten degrees from the horizontal, and is of such width and depth that it will carry away the overflow from the tank when inclined at the angle selected. The pitch of the trough must not be too great, for this would mean a high velocity through it, thus bringing about a large friction loss. However, it must be inclined sufficiently to carry away the pump delivery. If lined with zinc or copper sheeting, the sides of the trough will reduce the friction loss. Provision must be made for accurately measuring the depth of water in the channel or trough and a current meter for obtaining the velocity of the water in the channel is also necessary.

The water must start from the tank into the channel with almost no initial velocity; more accurate measurements are then possible. To provide for this condition a partition must be inserted across the short dimension of the tank, as described in the tank with the weir.

The most common type of drive for the small centrifugal pump is the electric motor. The connection to the pump is often by a belt long enough to allow 10 to 12 ft. from the motor-shaft center to the pump-shaft center.

The power input to the motor is measured by an ammeter and a voltmeter if using a direct-current motor, and by a wattmeter if using alternating current. In the direct-current system the voltmeter is shunted across the line at some convenient point near the motor and the ammeter is placed in series with the armature circuit. In the alternating-current system the wattmeter is placed in

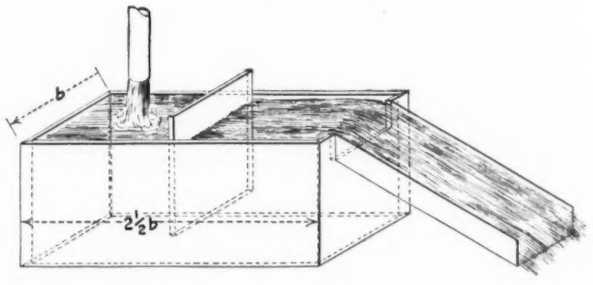


Fig. 2. Rectangular Weir with Trough

series with one of the windings. The reading must be multiplied by three if a three-phase circuit is used. In either system provision should be made to vary the speed of the motor.

If it is possible to substitute a direct-connected motor for the belt drive, better results will be obtained in that it will be possible to measure the power input to the pump more accurately. A convenient method is to insert between the motor and pump couplings a direct-reading

*When water escapes to the atmosphere or from one vessel to another through a "drowned" (submerged) orifice, or whether it flows from an open channel or nozzle, the stream will get smaller—contract at a certain distance from the orifice; hence the term contraction.

dynamometer which records the horsepower upon a graduated scale. However, this is a rather expensive apparatus and is necessary only when great accuracy is required.

A strainer and check valve should always be placed on the lower end of the suction pipe, Fig. 3. The strainer will prevent any large pieces of foreign matter being drawn into the pump. The valve will prevent the suction

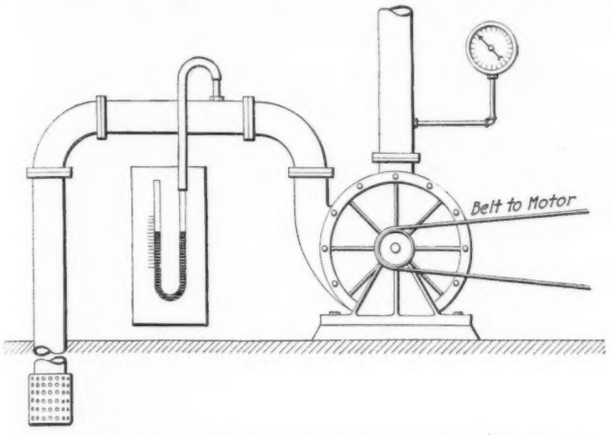


FIG. 3. U-TUBE FOR MEASURING SUCTION HEAD

head being lost, if the pump is shut down for a short time, and will also assist in starting the pump.

To measure the suction head a mercury column, consisting of a glass U-tube a little more than half full of mercury, is attached to the suction pipe as nearly as possible to the pump. A vacuum gage could be used for this purpose and attached to the same place on the suction pipe. A thermometer is needed in the well to determine the water temperature.

To measure the delivery head a pressure gage is attached to the delivery pipe near the pump. A throttle valve placed in the delivery pipe near its discharge end enables one to vary the pressure against which the pump

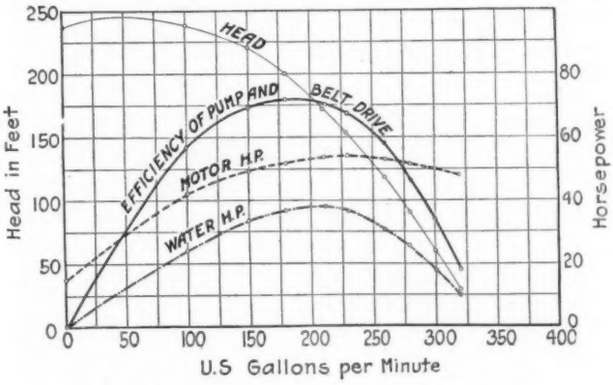


FIG. 4. HORSEPOWER-QUANTITY CURVES

works. Two speed counters are usually provided, one for taking the motor and the other for taking the pump revolutions.

An opening in the pump casing is necessary to provide for starting. This hole is fitted with a plug and should be from 1 to 1½ in. in diameter.

Having provided suitable apparatus, there are two tests that may be run—the constant speed and the variable speed.

CONSTANT-SPEED TEST

This is the most valuable test because a centrifugal pump is designed to run at a constant speed. Having filled the pump with water through the hole in the casing, open the throttle valve in the delivery pipe and start the motor. When the pump is running at its normal speed see that the throttle valve is wide open so that only the static head to the point of delivery and the friction head in the pipe exist. This will be the condition of largest capacity, smallest head.

The following readings are taken and repeated every two or three minutes for the same conditions until five are recorded, and for each new set of conditions: Voltage, amperage (if direct current is used), wattage (if alternating current is used), suction pressure, delivery pressure, speed of motor, speed of pump, and the necessary readings for determining the quantity pumped. One reading of the thermometer will usually be sufficient during the test, as the water temperature will vary slightly, if any.

The delivery throttle valve may now be closed to some extent to shut off the flow and correspondingly increase the pressure. Readings are taken at every 5-lb. increase

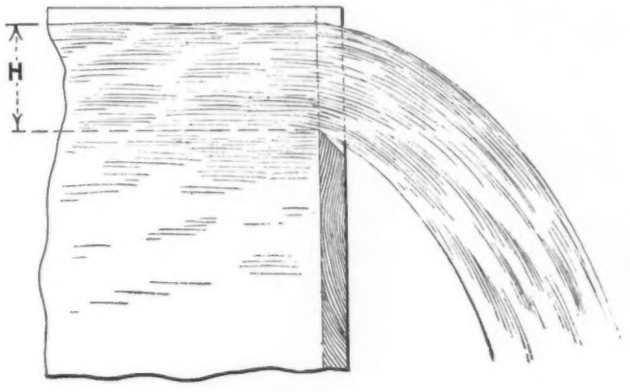


FIG. 5. SHOWING THE PROPER VALUE OF "H"

in the pressure to start with, and the interval may be decreased if found necessary when approaching the condition of maximum pressure, no quantity.

Care must be taken in starting the test when the valve is wide open, not to overload the motor by pumping too large a quantity. There are pumps with which it is impossible to overload the motor, as the motor horsepower—quantity curve—is of a form shown in Fig. 4. If a constant-speed motor is not being used, it will be necessary to slow down the motor as the quantity decreases, as the tendency will be to speed up the pump beyond its rating.

If the well from which the water is pumped is not of sufficient capacity, the level will fluctuate somewhat, provided the weighing-tank method is used. This will be noted only if the water pumped is let back into the well after being weighed.

Before finishing the test the height of the center of the pressure gage above the water level and also the height of the point of attachment of the mercury gage above this level should be recorded.

The following calculations will be necessary to convert the readings taken into terms for plotting the curves: Obtain from a table of the properties of water at different temperatures the weight of a cubic foot of water at the temperature recorded. With this figure the number of cubic feet pumped per second may be obtained from the pounds per second, if the weighing-tank method is used.

Number of Readings	Motor			Pump			Weighing Tank				Discharge, Speed, Ft. per Sec.	Pressure Head, Ft.	Difference in Elevation of Gages, Ft.	Suction Head, Feet	Speed Head, Feet	Total Head, Feet	Efficiency of Motor	Horsepower of Motor
	Current Input	Voltage	R.p.M.	Discharge Pressure	Suction Pressure in Hg.	R.p.M.	Time, Seconds	Weight of Water, Lb.	Pounds per Second	Cubic Feet per Second								

Number of Readings	Performance at N R.p.M.						Remarks:
	Total Head, Feet	Discharge		Horsepower of Motor	Water Horsepower	Water Hp.	
		Cubic Feet per Second	U. S. Gallons per Sec.			Motor Horsepower	

FIG. 6. FORM FOR RECORDING CENTRIFUGAL-PUMP TEST DATA

By the weir method of measurement the quantity may be calculated directly by the use of Francis' formula:

$$Q = 3.33\, b H^{\frac{3}{2}}$$

in which

Q = Cubic feet per second;
b = Width of weir in feet;
H = Height of water level above the weir.

Care should be taken that it is measured far enough back from the weir so that the true height is obtained, as in Fig. 5. An accurate method of obtaining height H is to measure the level of the water by means of a hook gage suspended over the center of the tank.

With the channel method of measurement the water cross-section must be determined in some manner, and this section in square feet multiplied by the velocity of the water in feet per second will give the flow or discharge in cubic feet per second.

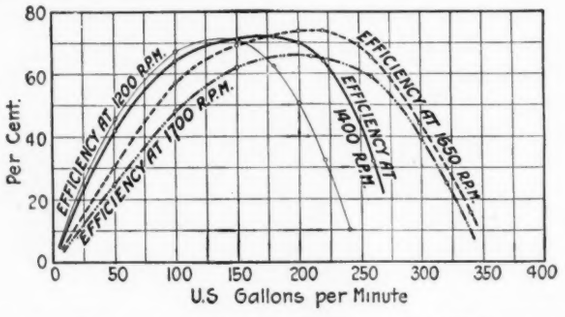


FIG. 7. RESULTS OF SPEED TEST ON 12,000-GAL.-PER-HOUR TURBINE PUMP

The pressure head P in feet is obtained from the gage pressure in pounds per square inch by multiplying the same by the factor 2.31. The suction head in feet is obtained from the suction pressure in inches of mercury by multiplication by the ratio 17 : 15.

The total head against which the pumps are working is obtained by addition of the suction head, pressure head and the vertical distance in feet between the center of the pressure gage and the point of attachment of the mercury gage. The friction head in the delivery pipe, the suction pipe, the foot valve and strainer are accounted for by readings of the pressure and suction gages.

The horsepower output of the motor, in the case of direct current, is obtained from the product of the amperage, voltage and motor efficiency, divided by the factor 746. The motor efficiency must either have been determined beforehand by separate test or obtained from the motor manufacturers. In the case of alternating current the motor output is the watts input times the motor efficiency.

The belt loss is subtracted from the motor output to find the true power input to the pump. This loss will depend upon the condition of the belt texture, the tension put upon the belt and the amount of slip. The variation of the ratio of the motor and the pump speeds gives some indication of the loss of power in the belt.

The water-horsepower exerted by the pump is obtained as follows:

$$\textit{Water-horsepower} = \frac{62.5 \times QH}{550} = \frac{QH}{8.8}$$

where

Q = Cubic feet water per second;
H = Total head on the pump in feet.

The efficiency of the pump is then the water-horsepower divided by the horsepower input to the pump.

Fig. 6 is a form showing the readings necessary and the factors to be calculated. Fig. 7 shows the curves obtained from an actual constant-speed test on a small turbine pump of 12,000 gal. per hr. capacity. Without doubt, it will be impossible to keep the pump at exactly a constant speed, and to plot the curves for constant speed it

will be necessary to correct the readings of quantity, head and horsepower by means of the following formula:

$$Q' = Q \times \frac{N'}{N}$$

$$H' = H \times \left(\frac{N'}{N}\right)^2$$

$$HP' = HP \times \left(\frac{N'}{N}\right)^3$$

where Q', H' and HP' are the quantity, head and horsepower at speed N', which is the constant speed at which the pump should run, and Q, H and HP are at the speed N, the actual speed recorded while the readings are being taken.

Variable-Speed Test

Such a test may be run when it is the desire to know at what speed the pump will give the best efficiency; in other words, for what speed the pump was designed.

The apparatus used in the former test can be used in this test. Commence at a speed somewhat below that which has been judged to be the normal speed of the pump, and with the valve wide open take readings of the power input to the motor, speed of motor, speed of pump, pressure gage, suction gage and quantity pumped. Take only one set of readings, and then increase the delivery pressure and take another set. Continue to increase the pressure, taking readings at every change until the throttle valve is entirely closed. Then open the valve, speed up the pump 50 or 100 revolutions and take the same readings as before with the same increases in pressure.

The calculations may be made by the same formula and rules as formerly, but in plotting the curves it will be necessary to plot only the efficiency curves to ascertain at what speed the pump should be run to work most economically. A set of such efficiency curves taken from a test is shown in Fig. 7. The normal speed of the pump was 1650 r.p.m., at which speed, as shown, the best efficiency was obtained.

One Thing to Remember is that if a man does not know, he cannot be cussed into knowing, especially if you have only a short time in which to give him the treatment. A better plan is to wait an opportunity, and not let it pass when it comes, to talk with the man and do your best to give him help by way of instruction and advice.—D. R. MacBain, before the Traveling Engineers' Association.

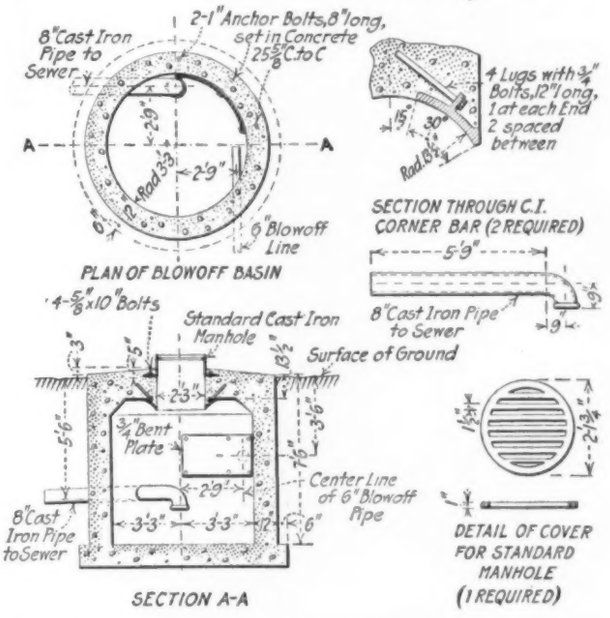
Three-Metal Bronzes—A description of the ternary metals: Copper and tin with lead, zinc, phosphorus, manganese and aluminum. Lead imparts plasticity to bronze, and diminishes hardness and temperature changes ("imparts a lower mutual freezing point"). Microscopic examination shows that the lead is distributed throughout the mass. Segregation, to which bronzes rich in lead are liable, is prevented by the addition of 1 per cent. nickel, sulphur added as galena, phosphorus, or arsenic. A small addition of zinc does not materially alter the structure of bronzes, while ductility and tensile strength are slightly increased. Bronzes containing zinc are more easily forged and cold-rolled and are less readily corroded by sea water. Phosphorus may exist entirely as solid solution (up to 1 per cent.) or as Cu_3P; it greatly increases the hardness and resistance to wear, while impairing the tensile strength, elasticity and elongation. The maximum in commercial bronzes is about 0.8 per cent. P, with about 8 per cent. Sn. The valuable properties of manganese bronze are its strength and noncorrodibility; commercial products often contain more aluminum than manganese. True aluminum bronze seldom contains more than 11 per cent. Al; it is useful in casting, though it shrinks considerably. The addition of tin increases its ductility.—"Journal of the Franklin Institute."

Concrete Blowoff Basin

By A. D. Williams

A blowoff basin or tank is one of those details of a power plant that often cause trouble. Restrictions are frequently imposed regarding the discharge of steam into sewers, and much steam is released where the blowoff pressure becomes equal to that of the atmosphere. The basin, Fig. 1, was designed for the East Fifty-third St. station of the Cleveland municipal electric-light plant and presents desirable features. It is constructed of plain 1:2:4 concrete, as it is buried in the ground. For use above ground the design must be modified and strongly reinforced concrete or steel plate used, the latter preferably.

This basin is designed to separate the steam from the hot water by whirlpool action; the blowoff pipe entering the basin tangentially, as shown in the plan section. The



Section and Details of Concrete Blowoff Tank

concrete is protected from the action of the entering stream by a ¾-in. bent plate. In action the water has a tendency to spread out on the walls of the basin, leaving the center open for the escape of the steam released. This action of the water explains the location of the cast-iron waste pipe close to the wall, where it will commence to take water to the sewer as soon as the whirling water covers it. The lip around the manhole and the curved top are designed to prevent the whirling sheet of water from spreading on the top and trying to climb out of the manhole. The curve and lip work upon the same principle as similar parts of a steam separator, and throw the water down into the tank.

To simplify the form work required in constructing the tank, the top may be chamfered as indicated by the dotted lines, at one side of section AA. In building a basin on this design the internal form is best constructed of sheet steel, galvanized or plain, held in place by a wooden skeleton built so that a man can work inside the form to place the concrete bottom of the tank. In this way any seam between the walls and the bottom can be avoided.

The basin is designed to receive the blowoff from six boilers with 10,134 sq.ft. of heating surface each. If desired, the inside diameter of the basin may be increased, but it would be inadvisable to reduce the diameter, as the blowoff water enters it at a high velocity.

Razing a Brick Chimney

An extremely hazardous method used by a wrecking company to raze a brick chimney is shown in the illustration. This chimney was 6x6 ft. inside and 125 ft. high, and belonged to an abandoned power plant. Fig. 1 shows the method used. The bricks were dug out one on side and three jack-screws placed in the opening; then those on the opposite side and also back to the center of the chimney were knocked out. The idea was to tip the stack over with the jack-screws, but too much of the brickwork had been dug out and the remaining bricks failed. The result was successive failures which let the stack down almost vertically, as shown in Fig. 2. The fountain-like upheaval of bricks in Fig. 3 would make it appear that the base was blown out from under the stack, but such was not the case.

Fortunately, no one was hurt by the premature falling of the chimney. There were two men on the scaffold when it started to collapse, but they jumped down and escaped from the danger zone. The top of the stack fell only forty feet from the base. This method is not to be favored, even when it is desired that the chimney fall within a small radius.

The whole circumstance furnishes a good illustration of the rule-of-thumb method used by many contractors, instead of making a few simple calculations. It is likely that this same process had been successfully used before on a small stack, therefore they supposed it would do for all others, but a method which proved entirely satisfactory in handling a small stack might not be at all successful for a large, heavy one. Many serious accidents have occurred in trying to adapt methods suitable enough in one case, but entirely inadequate in another. It is to be hoped that they will not experiment again.

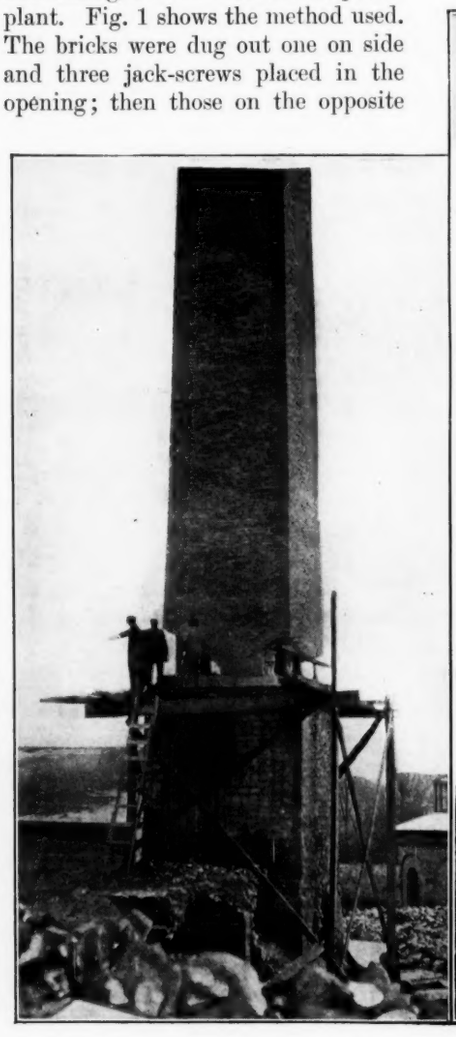


FIG. 1. METHOD EMPLOYED

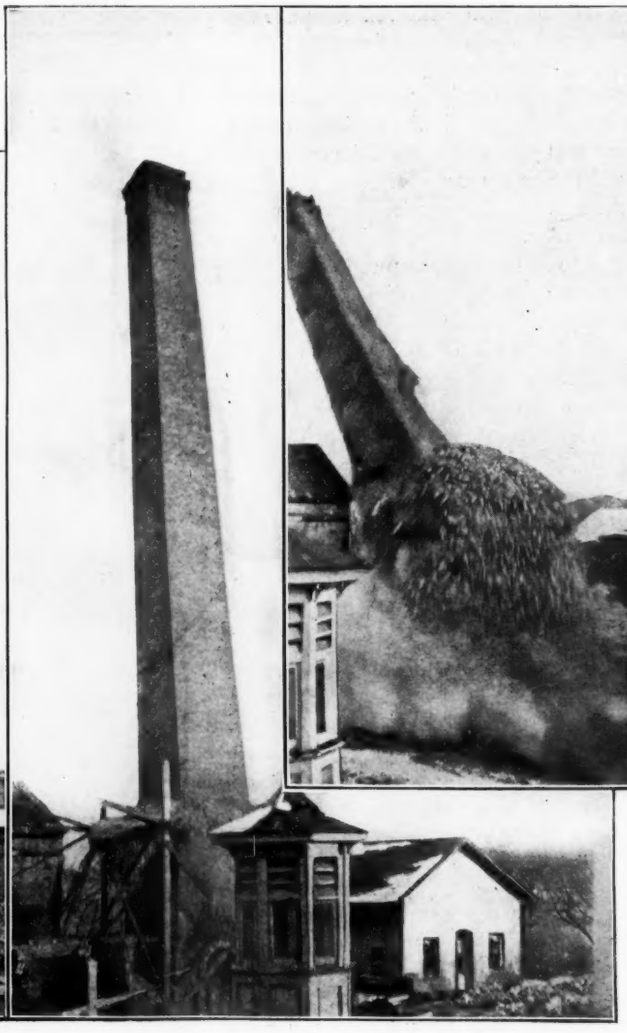


FIG. 2. BEGINNING TO COLLAPSE

FIG. 3. RESEMBLING AN EXPLOSION

Ocean Volume to Land Area—One per cent. of the contents of the oceans would cover all the land areas of the globe to a depth of 290 ft.—U. S. Geological Survey.

Two Causes for a Belt Not Running True upon properly built pulleys mounted upon correctly aligned shafting: The belt may not have been made straight in the first place, or the ends may not have been joined squarely. Otherwise there may have been a lack of uniformity in the texture of the hides from which the belt was made; belly leather toward one edge and flank leather toward the other, and the two stretching unequally.

Stop Acts When Rod Breaks

The value of a dependable safety stop on a steam engine was demonstrated a few days ago, when the piston rod of a 23x36-in. Wright engine parted. The engine was operating in the basement of the J. T. Perkins Co.'s factory, Kent Ave. and Hooper St., Brooklyn, N. Y.

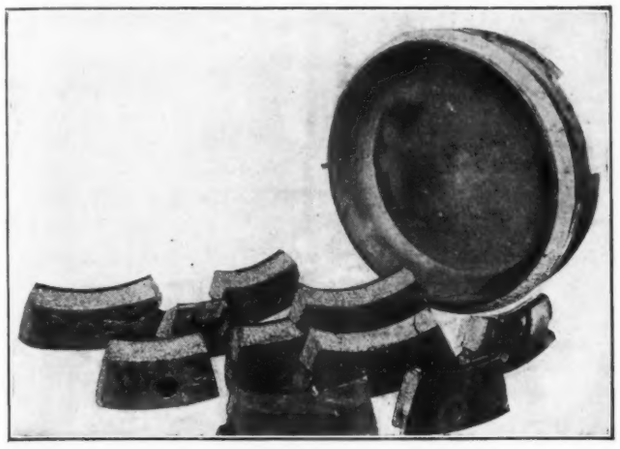


FIG. 1. CYLINDER HEAD AND PIECES OF THE FLANGE

The rod parted at the keyway in the crosshead, resulting in the knocking out of a cylinder head, breaking the flanged part into small pieces clean around the body of the head, as shown in Fig. 1.

No one was injured, and the property damage was slight. Fortunately, eight bales of camels' hair, weighing about 400 lb. each, were piled in line with the cylinder, and these received the head and piston as they were driven from the cylinder, and undoubtedly saved the lives of two operators who were working on a machine in line with the cylinder.

The engine was running at a speed of 90 r.p.m. with a boiler pressure of 125 lb. The piston rod shows on the face of the fracture that the break for the most part was old, the lighter surface at the right side of the right

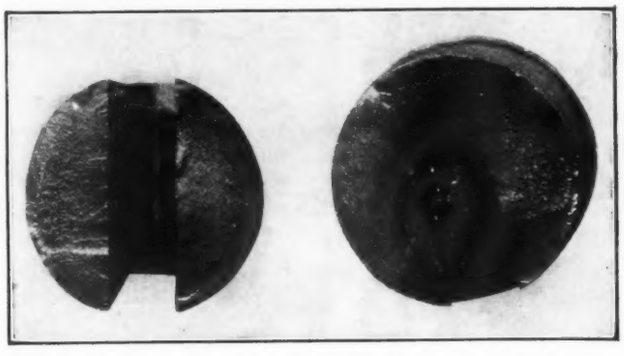


FIG. 2. THE LIGHT SHADING INDICATES THE NEW FRACTURE OF THE PISTON ROD

view of Fig. 2 indicating the new fracture in the metal. The break was evidently caused by ordinary working strains, the metal appearing to be of good grade.

When the rod parted, the Wright safety stop, which is designed to operate with both high and low speeds, threw the catch blocks on the steam valves out of action, allowing the valves to remain closed and so preventing steam from entering the cylinder.

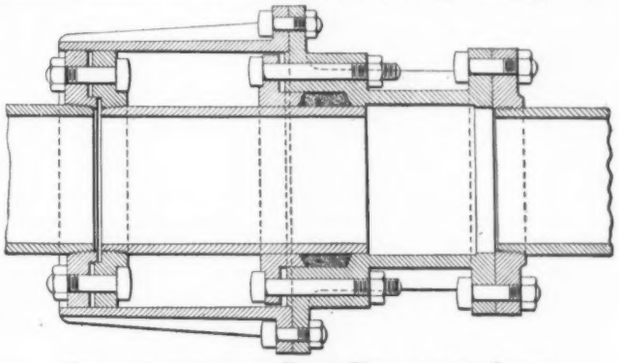
Because of the prompt action of the engine stop and the non-escape of live steam at boiler pressure into the factory, damage to the goods was prevented and the possibility of a panic and loss of life was avoided.

Ross Expansion Joint

The illustration herewith shows an expansion joint, the primary feature of which is that of guiding the pipe line so that it will be in alignment with that part of the piping which is held rigid, and thus prevent the ordinary wear and tear on packing experienced in slip-tube expansion joints. This joint automatically permits a lengthening or shortening of the pipe line to which it is applied up to a maximum of a 4-in. change of length without creating strains or distortions.

Referring to the illustration, the flanges, which are at each end of the joints, are of a size to permit of joining with the pipe-line flange on the larger end, the flange on the smaller end being bolted to a standard fitting which is anchored, or to the pipe line that is properly guided and anchored.

If it were not for the outer sleeve this device would be nothing more than an ordinary slip-joint, providing lineal



SECTION THROUGH ROSS EXPANSION JOINT

play for expansion and contraction. The slip-joint section, however, is of improved construction, as the packing space is ample and the slip tube is made of bronze, so that it will not rust in the packing.

The particular feature of this joint is the outside sleeve, which introduces an effective and rigid guide. This sleeve is cylindrical, machined on the inside and bolted to the body. The companion flanges, which travel in this guide, according to the amount of contraction or expansion of the pipe line, are machined on their peripheries to secure alignment, and wear of the packing of the slip joint and sagging of the line at the expansion joint are avoided. This prevents the tendency to leak and the joint will remain tight for long periods without adjustment of the packing.

This type of joint is made for a pressure of 200 lb. per sq.in., in all sizes up to and including 24 in. Each size will accommodate 4 in. of travel for expansion and contraction, and if a longer traverse is desired, special joints can be obtained.

This expansion joint is manufactured by the Alberger Heater Co., Chicago and Granger St., Buffalo, N. Y.

Idle Boilers should be thoroughly washed out and dried. Trays with unslaked lime should be placed inside and the boilers should be closed air tight. If the boiler is to stand ready for immediate use it should be filled with water to which burnt lime has been added, but unless the boiler is one of a battery and is kept warm, it is likely to condense atmospheric moisture from outside and corrode if filled with water.—Exchange.

Forty Years' Advance in Internal-Combustion Engines

Reference to the opposite page affords striking contrast between the internal-combustion engine of forty years ago and the present highly developed product in its special adaptations to various kinds of service. The two upper views represent the machines exhibited at the Centennial Exposition at Philadelphia in 1876, and among the rest are some that will be seen at the Panama-Pacific Exposition.

While the first attempts to produce an internal-combustion engine date back to the latter part of the eighteenth century, when gunpowder was used as the energy-producing medium, little was accomplished until 1860, when Lenoir placed on the market the first practical engine. This was horizontal, double-acting, and the cycle was patterned somewhat after the steam engine, the charge being drawn in during the first half of the stroke, ignited, and expanded during the latter half, then expelled on the return stroke. Owing to its extravagant use of gas, however, the Lenoir engine did not meet with much success.

The next engine to attract popular attention was the Otto and Langen, brought out in 1866. This was entirely different from the Lenoir and embodied the atmospheric free-piston principle. It consisted essentially of a long cylinder open at the top and containing a piston, the rod of which carried a rack. By means of a special clutch and pinion this rack was made to engage with the flywheel shaft on only part of the down stroke and that part of the up stroke during which the charge was being drawn into the cylinder. The operation was essentially as follows:

The mixture was drawn in for about one-sixth of the stroke and was then ignited by a naked flame, whereupon the rack disengaged from the pinion and the piston was projected upward; the latter part of the stroke, after the gases had expanded and cooled, being due to the inertia of the piston. On the downward stroke the rack engaged the pinion and the weight of the piston, aided by the atmospheric pressure on its upper side, performed useful work and stored energy into the flywheel. As the pressure of the gases below the piston increased above the atmosphere, they were slowly expelled from the cylinder and the speed of the piston decreased. At this point the pinion disengaged, only to engage again at the beginning of the up stroke for drawing in the next charge. The admission of the charge, ignition and exhaust were controlled by eccentrics and there were about 20 strokes per minute.

The engine was essentially limited in output and a great drawback was its irregular and extremely noisy operation. This led Otto to bring out, in 1876, a new engine operated on the four-stroke cycle (Beau de Rochas cycle) which was destined to revolutionize the gas-engine industry. It was the first gas engine to use compression and in principle formed the basis of the modern internal-combustion engine.

Just previous to this, however, in 1873, a Philadelphian by the name of Brayton brought out an oil engine in which the oil and air were mixed under considerable pressure outside the engine and passed into the cylinder through a fine-mesh wire screen, burning just beyond it, the object of the screen being to prevent backfiring into the port. The mixture was admitted for practically one-third the stroke and burned at a uniform pressure. The inlet valve then closed and the heated products of combustion forced the piston to the end of the stroke. The exhaust port opened just before the end of the stroke and on the return stroke compression was carried to the pressure in the air and fuel tanks.

Engines of this type were built in sizes of 1 to 10 hp., and were extensively used, the chief troubles being backfiring and the extinguishing of the pilot flame. Also, the addition of compressors for the oil and air made the installation somewhat cumbersome.

Without attempting to enumerate or describe the intermediate steps in the development of the gas and the oil engine, associated with the work of Dugald Clerk, Dr. Diesel and others, we will pass to a consideration of some of the present-day types. The familiarity of the reader with the principles of operation involved and their general construction makes a description unnecessary; hence, space will be devoted only to certain comparative features, some of which are included in the following tabulation:

COMPARATIVE FEATURES OF DIFFERENT TYPES

Type	Cylinders	Horsepower	Weight	Weight per Horsepower	Fuel Consumption
Otto	Single, single-acting, 9 in. x 5 ft. 10 in.	3			28 cu.ft. coal gas per hp.-hr.
Brayton	Double, tandem, vertical, 6x9-in.	8			About 2 lb. per hp.-hr.; oil of 0.85 sp.gr.
Automobile	6-cycle, 3½x5-in.	35 hp. at 1800 r.p.m.	500 lb.	14.5 lb.	
Aeroplane	8-cyl., 5x7-in.	200 hp. at 1700 r.p.m.	650 lb.	3¼ lb.	0.1 gal. per hp.-hr.
Farm	Single	6 hp. at 350 r.p.m.	155C lb.	258 lb.	
Blast-furnace gas	Twin-tandem, 44x60 in.	5000 hp. at 83¼ r.p.m.	1,900,000 lb.	380 lb.	
Diesel	4-cyl., 19x24½-in.	500 hp. at 200 r.p.m.	181,000 lb.	362 lb.	0.408 lb. per hp.-hr.

The automobile has been responsible for the development of the gasoline engine to a high state of perfection during the past ten years, the motor shown representing one of the standard makes. In accordance with the latest practice, this is a long-stroke, high-speed type with cylinders cast *en bloc*, and weighs only 14½ lb. per horsepower.

Since the practical application of the aëroplane followed closely that of the automobile, the experience with the latter was invaluable in the design of a motor for the former. The departures were essentially in the reduction of weight, increase of power and provision for continued operation at maximum load. The engine shown represents one of the most successful American designs, in which the weight has been reduced to 3¼ lb. per horsepower and the fuel consumption to 0.1 gal. per horsepower-hour—another vital point in aëroplane work.

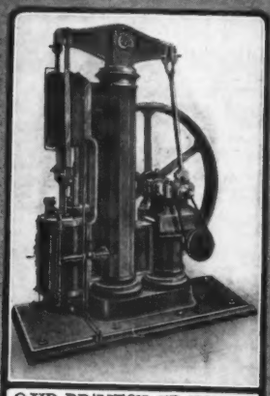
The farm engine, on the other hand, had been developed with a view to ruggedness and foolproof operation, with fair economy and little attention to weight. The

EVOLUTION of the INTERNAL-COMBUSTION ENGINE

FLOOR SPACES ARE APPROXIMATE

1876

Floor Space 10 sq. ft.



8-HP. BRAYTON OIL ENGINE

Floor Space 18 sq. ft.

3-HP. OTTO GAS ENGINE

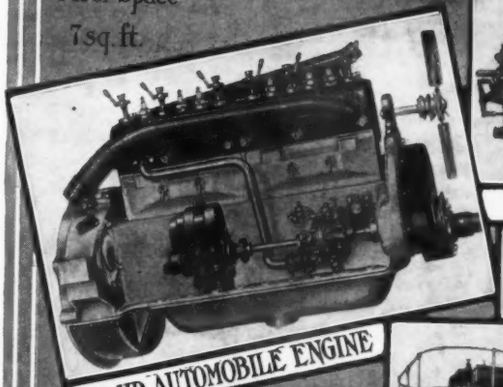
Floor Space 5 sq. ft.

Floor Space 7 sq. ft.

6-HP. FARM ENGINE

Floor Space 14 sq. ft.

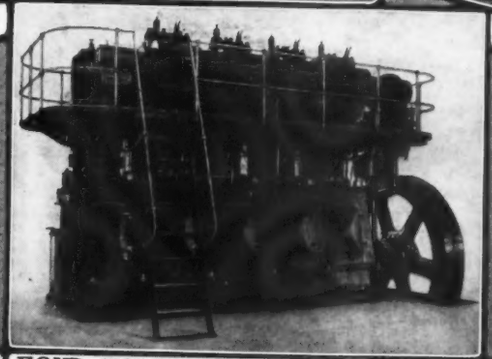
1915



35-HP. AUTOMOBILE ENGINE

200-HP. AEROPLANE ENGINE

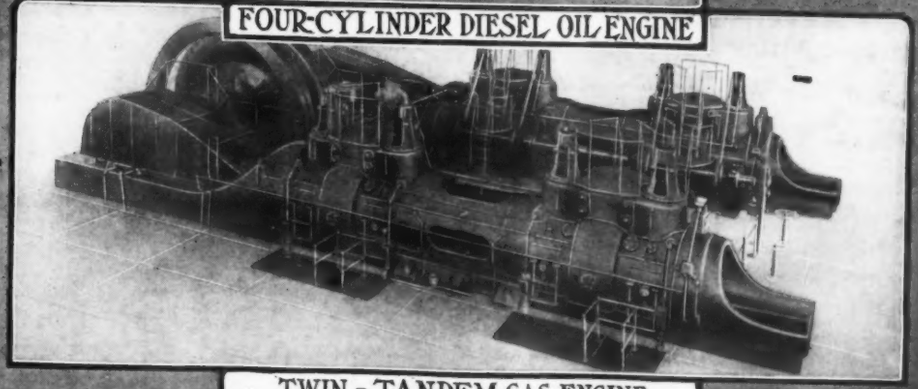
Floor Space 112 sq. ft.



FOUR-CYLINDER DIESEL OIL ENGINE

500 Hp.

Floor Space 2625 sq. ft.



TWIN - TANDEM GAS ENGINE

5000 Hp

6-hp. engine shown, which is representative, weighs two and one-half times that of the 200-hp. aëroplane motor and three times that of the 35-hp. automobile motor.

The 5000-hp. gas engine is one of a number of similar units operating on blast-furnace gas and driving generators and blowers at the Gary plant of the U. S. Steel Corporation, and represents one of the largest of its kind now in operation in this country. Owing to the size of the cylinders, 44x60 in., and the pressures involved, the construction is necessarily heavy, and it is probable that 5000 hp. will be about the limit for engines of this type.

Just as the Otto engine was the pioneer in the gas-engine field, so was the Brayton in the oil-engine field. It needed, however, the genius of Dr. Diesel and the untiring efforts of the manufacturers who took up his patents to produce what is today the most highly efficient heat engine in existence. To obtain this economy extremely high working pressures are required—500 to 600 lb. per square inch as compared with 50 lb. in the Otto and slightly more in the Brayton. This necessitates heavy construction, the engine shown, which is one of American make that is being exhibited at the Panama-Pacific Exposition, weighing 362 lb. per horsepower.

Firing Low-Grade Fuel and Wastes

By Sterling H. Bunnell

Much has been done toward operating steam-boiler furnaces on wastes of various plants, in utilizing slack and culm or coal-mine wastes and in developing power from city garbage. The question of economy is of first importance in deciding whether or not a low-grade fuel should be used. There are three elements to be considered; namely, the quantity of heat which can be produced per pound of fuel, the efficiency with which this heat can be transmitted to the boiler, and the cost of the fuel put into the furnace. Coal at $3 per ton delivered at the fire room and having a heat value of 10,000 B.t.u. per pound and fired in a furnace under conditions which give 70 per cent. boiler efficiency, must be fired at the rate of 10,000 divided by 0.70, or 14,300 B.t.u. of coal to put 10,000 B.t.u. under the boiler; and as 2000 times 10,000 B.t.u. cost 300c., the cost of 14,300 is 0.214c. Assuming that it costs 30c. to fire a ton of this coal, the cost of the coal in the furnace should be increased by $\frac{30}{3000}$, or $\frac{1}{10}$, making 0.235c. to put 10,000 B.t.u. into the boiler.

In comparison with this coal, suppose a fuel to be obtainable at 50c. per ton, giving only 4000 B.t.u. heat value per pound and capable of being fired with a boiler efficiency of 50 per cent. The computation shows 20,000 B.t.u. required to put 10,000 B.t.u. into the boiler; so, as 8,000,000 B.t.u. cost 50c., 20,000 will cost $\frac{1}{8}$c. If this fuel costs 50c. per ton to fire, it will be necessary to add $\frac{50}{50}$, or 100 per cent. to obtain the cost of 10,000 B.t.u., making the amount 0.25c. There is no money in firing this fuel under these conditions, as the cost is slightly more than the cost of good coal. It would, however, be desirable to use the low-grade fuel if it were a waste accumulating like sawdust and wood refuse in wood-working factories, in which case it would cost less to burn it than to cart it away. If the value of the fuel were 6000 B.t.u. per pound instead of 4000, it would figure $\frac{1}{12}$c. for fuel and the same for firing, making 0.166c. for 10,000 heat units delivered to the boiler as compared to 0.235c. for the coal at $3 per ton.

In every case it is important to consider all the conditions in connection with the various fuels which can be obtained, not forgetting that good coal can be fired by average firemen, while low-grade waste requires special skill to handle it successfully.

The mechanical difficulties in burning low-grade fuel are important and must be met by special construction and firing methods. Fine coal and dust tend to fall through the grates, no matter how small the openings are made. These fuels also tend to pack together, making a strong draft necessary to force air through the fire. Agricultural wastes, like spent tan bark, often contain a weight of water equal to or greater than the combustible. It costs as much to evaporate water in the fuel as in the boiler.

The draft for burning most kinds of low-grade fuel should be strong. The worst and wettest garbage is successfully burned in furnaces supplied with forced ashpit draft under pressures of 2 in. and more of water. If means can be provided to heat the air before entering the ashpit, by using waste heat from the flue gases, the combustion in the furnace is improved. The moisture content of the fuel should be reduced as much as possible. Sometimes this advantage can be gained by a change in the mechanical operation producing the waste. If not, it is usually necessary to fire the fuel as it comes, regardless of the quantity of water it may contain, as fuel-drying operations on a large scale are practically impossible. One instance to the contrary, however, is the burning of sewage sludge, which is first dried by passing it through a rotary drier in which hot flue gases circulate. Sewage sludge, however, has no heat value, and is burned merely to dispose of it without nuisance.

With most materials containing much moisture the drying must take place in the furnace and this requires careful watching and stoking. Sometimes a drying hearth can be provided on which the wet fuel can be first charged and allowed to dry in the direct heat of the fire. It is important to observe that the fuel must not be burned faster than it can be dried, or the fire will soon be blocked and extinguished by wet material. The fireman must, therefore, manage to keep a brightly burning fire of dried fuel and to supply wet fuel so that most of the moisture will dry off before the fresh material is charged on to the burning surface.

A common difficulty with low-grade fuel, particularly coal waste and the rubbish from cities, is the presence of mineral matter which forms clinker. With good coal the proportion of noncombustible substance amounts to only a small percentage, not enough to form very bad clinker. Factory ashes from well handled fires contain only a small fraction of unburned carbon and are finely divided into small particles. From the average house furnace, however, the ash contains one-half or more of combustible carbon. Such ash, fired in a suitable furnace with forced draft, would be of commercial value. As the combustible portions of low-grade fuel burn away, the areas of worthless ash and clinker remaining become larger. The melting clinker tends to inclose particles of unburned coal and prevent air from reaching it. With all low-grade fuels, therefore, the fire must be carefully watched, and the free passage of air through it must be maintained by stoking, and breaking up areas where combustion is giving out from lack of accessible fuel.

Editorials

Flywheel Explosions

In the power plant the boiler is commonly regarded as the most dangerous part of the entire equipment. Probably nine out of every ten engineers are of this opinion, and it is not surprising, as the number of boiler explosions in this country is excessive, the casualty list is large and the value of property destroyed is greater by far than in other lands, where rules for safety are more rigidly and uniformly enforced. From people who should know, however—men dealing every day in power-plant accidents—comes the surprising information that the flywheel is more dangerous than the boiler. In other words, the ratio of flywheel explosions to the number of flywheels installed is greater by one-third than that for boilers. This does not refer to totals, as boiler explosions would then have the lead by a large margin, owing to the greater number of boilers installed.

Viewing power-plant safety from this standpoint, it is evident that more attention is due the flywheel. Every boiler has its safety valve, and if statistics are of any value every flywheel should have at least equivalent protection.

The potential energy stored in the flywheel is tremendous, although, owing to the swift and even turning, appearances are to the contrary. There is no indication of danger, and as a result, proper precautions are not often taken. The rim velocity of an average flywheel is close to a mile a minute and it is seldom that a wheel explodes at a velocity lower than three miles per minute, or 264 ft. per second. The damage that might ensue from the heavy pieces of disrupted wheel moving at this terrific velocity may, perhaps, be imagined. Numerous articles in the past have recounted the actual results.

Property damage, however, is only a minor consideration when compared to the safety of employees. For every flywheel explosion the average is one man killed or injured, and the toll for the year is so heavy as to warrant every precaution which will tend to prevent these accidents.

The function of the governor is to control the speed of the engine and with it the flywheel. Usually, there is also included a safety provision to guard against emergencies, but this is a secondary consideration in the design, and there are certain contingencies which it will not take care of. With this single protection against accident, derangement of the valve gear or failure in the governor's own mechanism may result in disaster. An independent device is needed to make safety doubly sure, and this device is the safety stop.

When the engine reaches a predetermined speed, the stop automatically shuts off the steam and relieves the engineer of the dangerous task of trying to close the throttle under emergency conditions. If the governor fails to work, the stop is on guard to prevent destruction. In military circles the secret of success lies in a strong reserve to supplement and reinforce the first line. In the engine room the stop occupies the same position. It is ready to come to the rescue of the governor, and if kept in good working condition it will reduce the number of accidents and afford added protection to the engineer.

Neglecting the damage to property and the interruption of service usually resulting from a flywheel explosion, the device is warranted from the standpoint of safety. At best, power-plant work is dangerous and there are few places in which the "safety-first" slogan is more urgent. The life of at least one engineer every week is surely worth saving, and if the installation of safety stops will effect even a small reduction in the fatalities, there is not a power plant in the country which should not have one. It is due the engineer, and incidentally, the reduction of property loss may be worth while to the owner.

Compulsory Boiler Inspection

In most of these United States a man may buy any old kind of a boiler that he wants to, new or second-hand, have it set up by the local plumber, hire the hunk to run it who will do it for the least money, and put any amount of pressure upon it that he sees fit.

It may be said that ordinary business prudence and fear of damage to himself and his own people and property would preclude a man from taking too long chances; but any government or insurance inspector can tell of numbers of death traps set by the cupidity or, in justice be it said, more often by the ignorance of the boiler user.

Last year the inspectors of the Hartford Steam Boiler Inspection & Insurance Co. condemned outright 756 boilers as unsafe to use, and pointed out 23,012 defects involving the safety of the boiler.

In the same time the inspectors of the Fidelity & Casualty Co., of New York, condemned outright 340 boilers and pointed out 11,130 serious defects.

This, after the boilers had been prepared for inspection by the agents of their owners. These are only two, but the largest two, of a number of companies carrying boiler insurance. There are nine such companies doing business in Massachusetts.

Is it not reasonable to suppose that, if these boilers had not been inspected by specialists, there would have been a considerable addition to the loss of life and property by boiler explosions?

It is true that boilers which have been insured and inspected have exploded. Inspectors are human and fallible. They may overlook obvious faults, and there are hidden cracks in lap seams and flanges which the best of them could not detect; but this is no reason for condemning the whole system and renouncing the good which they are doing.

If the inspection incidental to insurance has revealed this number of serious defects, why would not an equally thorough and efficient inspection of uninsured boilers reveal an equally large proportion of defects and obviate an equally large proportion of explosions?

Are the boilers whose owners take a chance apt to be

better selected, installed and operated than those whose owners take the precaution to insure them?

In Massachusetts 17,969 boilers are inspected by the insurance companies. The state inspects the rest of them, 6723, itself. This is what all the states ought to do. Public safety ought not to be left to the "ordinary business prudence" of any man in the matter of boilers more than in storing and using gasoline or explosives.

A boiler full of hot water under pressure is just as dangerous under a sidewalk or a building as a keg of gunpowder.

The necessity of governmental regulation seems too obvious to question. Everybody does it but us.

Safety-Valve Capacity

One of the hardest nuts which the American Society of Mechanical Engineers' committee, while preparing the standard boiler code, had to crack was the question of safety-valve capacity. Previous to the last annual meeting the manufacturers of safety valves got together and said: "Now, let us go at this thing scientifically. What has a safety valve to discharge?"

"Steam."

"How much steam?"

"As much as the boiler can make—and then some."

"How much can the boiler make?"

"Ah! that depends upon the boiler, and the furnace, and the fuel, and the air supply, etc. But if we take the heat value per pound of the fuel and multiply that by the number of pounds which can be burned under the boiler per hour, multiply that again by the combined efficiency of the boiler, furnace and grate, and divide the product by the difference between the total heat per pound of steam as made and the heat per pound in the feed water, we shall find the amount of steam made per hour. Then we can give them a table of the discharge capacities of our valves of different sizes, and they can tell right away how many valves, of what size, it will take to discharge this amount of steam."

But the discharge capacity of a valve depends upon its lift, and there are makers who believe in high lifts and those who do not. After long discussion the valve manufacturers agreed unanimously upon the table of capacities which appeared in the third and fourth reprintings of the tentative report of the committee.

The proposed method evoked storms of protest. The conception of the country pipe fitter struggling with the B.t.u. per pound of fuel, the heat of the liquid and of evaporation, and the possible effect of draft on rate of combustion, was a little too much. The government and insurance inspectors vowed that it would take longer to inspect the safety valve than it would the boiler.

The question was therefore turned back at the safety-valve men, and they, unable again to meet upon a common ground as to a standard rate of discharge for safety valves, have presented a table giving the discharge in pounds per hour at minimum, intermediate and maximum lifts. The three-inch valve of no manufacturer shall lift less than five-hundredths nor more than one-tenth of an inch at one hundred pounds gage, and it is guaranteed to discharge certain amounts per hour at each of these lifts and the average of them.

At its rated capacity a boiler is expected to evaporate about three pounds of water per square foot of heating surface. In some of the large stations they are evaporating ten or more. If it be assumed that any boiler may possibly be subjected to this rate of evaporation some time in its life, and the amount of steam to be provided for by the safety valve be assumed at ten times the number of square feet of heating surface, the calculation would become an extremely simple one. A boiler having one hundred square feet of heating surface might possibly be subjected to conditions under which it would evaporate ten thousand pounds of steam per hour, and to discharge this would, by the table submitted, require one four-and-one-half-inch or two three-inch valves, at one hundred and fifty pounds gage pressure.

This gives somewhat more valve area than is common in ordinary practice, and ordinary practice seems to be good enough, for we never knew of a boiler which exploded for want of safety-valve capacity when the safety valve was operative at all. The modern high rate of combustion is provoked and intentional, and can be attained only purposely by well managed fires urged by artificial draft. A boiler even in the heart of a conflagration would not accidentally do as much. A smaller though somewhat less convenient factor than ten would doubtless have to be used, but it would seem that the heating surface is the logical measure of the safety-valve capacity. The grate area may be changed from time to time, oil or gas may be used, the boiler may simmer under a natural draft or fume under the action of a blower, the fuel may vary from wet tanbark to oil or natural gas, but the number of square feet of heating surface is always the same, and if the boiler is provided with safety-valve area to take care of all the steam which that heating surface can generate, it will make no difference who gets the boiler or what he does with it, as far as this phase of the question is concerned.

Committee work in engineering organizations is usually hard, tedious and trying, but the fellow who never did any is the one who most loudly proclaims that it's a sinecure.

Beats all how some engineers can go through most of their lives telling themselves they do not need to keep studying the progress of their calling, and then suddenly become most enthusiastic over engineering educational work. In nine cases out of ten you will find that the change of front is due to the central station making a strong bid for their jobs.

Several inquiries have come to us regarding the decision of the American Manufacturing Company, of Greenpoint, L. I., to discontinue running its power plant and to purchase power from the Brooklyn Edison Company. It would seem that the amount of power here used could be generated on the spot more cheaply than a public service company could furnish it, and we sought an interview with the officials of the company for the purpose of learning, if possible, the facts which led to the decision. The only statement which was forthcoming was that it had been made to the advantage of the American Manufacturing Company to purchase its current from the Brooklyn Edison Company and that there was nothing to discuss regarding comparative costs. The mere cost of production is not always the controlling factor in the interrelations of Big Business.

Correspondence

Transformer Connections

After reading Mr. Fox's article on transformer connections in the issue of Jan. 12, I feel that although his process of testing the polarity of transformers and grouping them to obtain various results is instructive, it could be somewhat improved by adding a simplified method for remembering the various connections and ways for determining when the devices are connected properly.

The opinion seems to exist among practical electricians with a limited knowledge of electrical theory, that there is one particular kind of parallel and series connections for batteries and some other kind for transformers or other devices; but this is not true, as there is one hard and fast rule that applies to all. When batteries are connected in parallel all positive terminals are connected together, likewise all negative terminals, and then a positive and a negative lead are brought out from the group as indicated in Fig. 1. What is true for this is also true for any other electrical device, from which the rule for parallel connection may be obtained, namely, connect like poles to like poles and bring out two unlike leads.

In connecting batteries in series a positive terminal is connected to a negative terminal until all are connected except one negative and one positive; these two are connected to the device to be operated. This is indicated in Fig. 2 and is true for any device, from which the law for series connections is obtained, namely, connect unlike poles until but two remain unconnected; bring these two out to the load.

When transformers are connected in parallel or series it is first necessary to determine which are like poles. After the transformers have been set symmetrically, consider all right-hand terminals of one polarity, say positive, and all left-hand terminals of the opposite polarity; then proceed as though connecting batteries, as indicated in Fig. 3, which shows two transformers connected in parallel. By comparison with Fig. 1 it will be seen that the grouping is similar. There is always a chance of the leads being brought out of the transformers to give the wrong polarity, and to guard against a short-circuit, connect a piece of two- or three-ampere fuse-wire in the low-voltage side as shown at *f*, Fig. 3. Then close the primary circuit with the secondary disconnected from the load, and if the connections are correct the fuse will not blow.

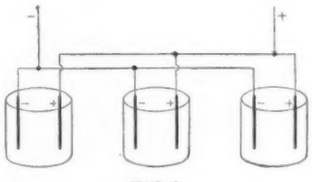


FIG. 1.

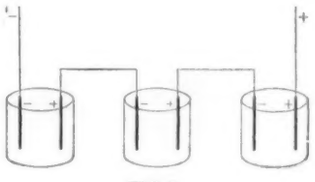


FIG. 2.

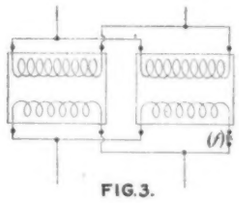


FIG. 3.

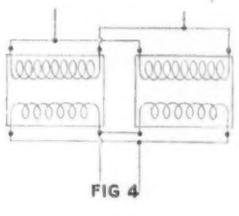


FIG 4

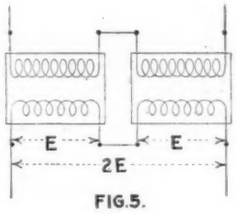


FIG. 5.

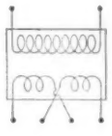


FIG. 6.

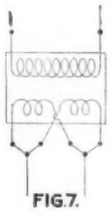


FIG. 7.

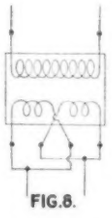


FIG. 8.

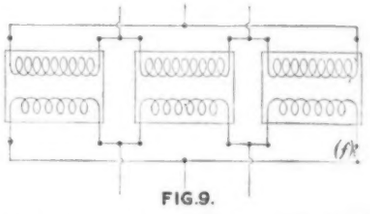


FIG. 9.

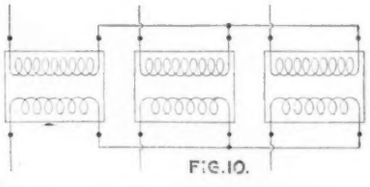


FIG. 10.

CONNECTIONS OF TRANSFORMERS

If the fuse blows, cross either the primary or the secondary leads of one transformer as in Fig. 4; this will correct the defect, irrespective of which transformer had the wrong polarity. A test lamp or voltmeter may be used in place of the fuse. If the connections are correct the lamp should not light nor the voltmeter read. The fuse, however, is not only the most likely to be at hand, but is also the most reliable, as there is always a chance of a defective lamp or instrument.

When transformers are connected in series the same rule is followed as in batteries, and by comparing Fig. 5 with Fig. 2 it will be seen that the same relation of connections is maintained in both cases. However, if the leads are brought out of one transformer to give the wrong polarity, the proper voltage relation will not be obtained on the secondary side, which should be as indicated, and instead of the voltage being 2E between the two outside terminals, it will be zero. This can be remedied by crossing the secondary or primary leads on one of the transformers.

There are usually four leads brought out on the low-voltage side of all small commercial transformers; the two center leads being brought out crossed as in Fig. 6. This brings the like terminals of each coil adjacent to each other and eliminates crossing them on the outside when the coils are connected in parallel as shown in Fig.

7. Care should be taken not to connect the two terminals of each coil together as in Fig. 8, for this would be a dead short-circuit.

It may be easy for those familiar with the laws of graphics and alternating currents to depend upon connecting transformers so that they form an angle of 60 or 120 electrical degrees to each other to obtain a delta or star-connection on a three-phase circuit; but for the man that does not possess this knowledge, the fact that the delta connection, as far as the grouping is concerned, is nothing more than a short-circuited series connection should greatly simplify the matter, as will be understood by referring to Fig. 9. The three transformers are connected in series as are the batteries in Fig. 2, but instead of bringing out the two outside terminals to the load as in the battery connections, they are connected together to form a complete loop with a lead brought out from each junction point. To make sure that the connections have been made properly and the transformers are all the same polarity connect a piece of fuse wire as at *f;* if the fuse does not blow the connections are correct and the transformers are of the proper polarity.

The making of a star connection may be greatly simplified if it is remembered that like terminals of the transformers are connected together (it may be either the right-hand or the left-hand terminal) and the other three terminals are brought out to the line as in Fig. 10, which shows the three right-hand terminals connected, with the three left-hand ones brought out to the line.

A. A. Fredericks.

New York City.

Boiler Explosion at Menlo, Iowa

A disastrous boiler explosion occurred at the electric-light plant at Menlo, Iowa, shortly after 6 p.m., Feb. 14, killing three men instantly and completely demolishing the power house.

The boiler was of the return-tubular type, of 60-hp.

Fig. 1. Wreckage after Boiler Explosion

capacity. The safety valve was set at 95 lb. The rupture occurred in the rear sheet, which ripped entirely around where it joined the middle sheet, and was thrown a distance of about 300 ft., breaking a number of telegraph lines in its descent. The rear flue sheet was thrown a distance of 600 ft., and fell through the roof of a dwelling shown in Fig. 2 and landed in the kitchen. A heavy stop valve fell in the yard of the same residence. As the explosion occurred at the supper hour, the occupants of the house were seated at the table in an adjoining room and no one was injured.

The power house stood some distance from other buildings and being constructed of heavy concrete, the injury to the surrounding property was slight, consisting of some damage to roofs due to falling pipes, brick, etc. The heavy concrete walls, together with the fact that the boiler was set below the ground line, undoubtedly prevented much damage to the adjoining property.

No definite cause is known for the explosion, as all those who might know were killed. The boiler was about 18 years old and fairly clean and free from scale. The men were evidently sitting directly in front of the boiler, judging from the position in which the bodies were found.

Fig. 2. The Tube Sheet. Fig. 3. The Rear Circular Sheet Near Railway Track. Fig. 4. Close View of Pitted Sheet

Had the accident occurred a few minutes later it is likely the loss of life would have been much greater, as it was the custom of a number of the employees and others to spend some time at the plant after the supper hour.

S. Kirlin.

Stuart, Iowa.

[Figs. 2, 3 and 4 were received later from J. C. Bruff, Atlantic, Iowa, without additional information as to the probable cause of the explosion.—Editor.]

Some Reasons for Different Rates

There appears to be a prevalent idea that central stations sell power below cost to large consumers and make up the loss by charging the small ones high rates. It doesn't seem to occur to some of these people, however, that if this were true it would be a wise policy to cut out the large consumer and make a still larger profit.

The average power company has a scale of many different rates to cover different conditions, and the writer will attempt to explain the reason for some of them. To make the explanation more simple, he will compare the product and sale of electricity to ice. Let the square figure represent a pond with a crop of ice. Jones, the iceman, builds up a trade from house to house to sell in lots of 50 to 100 lb. daily from his wagon and will cut the area marked *A*. He also looks over the grocery and provision markets that will take 200 to 500 lb. daily and estimates that the area marked *B* will supply them. There is likewise a large demand from the ice-cream factories and soda fountains, each of which will require 1000 to 2000 lb. per day, and he secures that business, requiring him to cut area marked *C*.

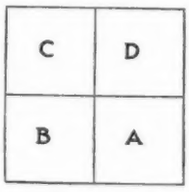


DIAGRAM REPRESENTING POND

In the town where Jones does business Smith and Brown have small icehouses which are badly in need of repair, and it occurs to them that Jones can harvest the balance, or area marked *D*, cheaper than they could harvest their own, so they arrange to take that amount from Jones. To harvest ice marked *A*.

Cost of labor per ton	$1.00
Cost of machinery, house and other equipment per ton	1.50
Total cost per ton	$2.50

To harvest *B*, in addition, will require another story on the icehouse and the labor will be more efficient, making

Cost of labor per ton	$0.85
Cost of machinery, house and other equipment per ton	0.85
Total cost per ton	$1.70

To harvest *C*, in addition, will require another story on the icehouse and the labor will continue to become still more efficient, making

Cost of labor per ton	$0.75
Cost of machinery, house and other equipment per ton	0.60
Total cost per ton	$1.35

To harvest *D* will require another story on the icehouse, still using the same machinery as at first, and there will be a slight improvement in labor, making

Cost of labor per ton	$0.70
Cost of machinery, house and other equipment per ton	0.45
Total cost per ton	$1.15

Leave out the shrinkage and other losses before summer and consider the delivery.

A two-horse team is worth $5 per day and two men will cost about $5 more, making $10. These will make two trips per day, delivering one ton per trip to householders taking 50 to 100 lb. of ice. The usual rate to consumers of small quantities is about $8 per ton, so it is easy to figure the profits:

Two tons at $8 per ton		$16.00
Cost of two tons at $1.15	$2.30	
Cost of team	5.00	
Cost of two men	5.00	
		12.30
Gross profit		$3.70

The rate to markets which take 200 to 500 lb. may be $6 per ton, and a similar team would make three trips per day, or deliver three tons, the profit working out as follows:

Three tons at $6 per ton		$18.00
Cost of three tons at $1.15	$3.45	
Cost of team	5.00	
Cost of two men	5.00	
		13.45
Gross profit		$4.55

The rate to ice-cream factories and soda fountains, which take 1000 to 2000 lb. at a time, and allowing the team to make five trips daily, may be $4 per ton, working out as follows:

Five tons at $4 per ton		$20.00
Cost of five tons at $1.15	$5.75	
Cost of team	5.00	
Cost of two men	5.00	
		15.75
Gross profit		$4.25

Now Smith and Brown have arranged to take their own ice from the house, using about ten tons each per day, and Jones made them the ridiculous price of $2 per ton; but the profit comes out as follows:

10 tons of ice at $2	$20.00
Cost of 10 tons at $1.15	11.50
Gross profit	$8.50

It is evident that Jones cut down his cost by harvesting the whole field, and if he had stopped at *A* he would have had to charge at least $10 per ton to householders, to make a reasonable profit.

On the other hand, he could not charge the markets, ice-cream factories and Smith and Brown (whose business caused the whole lot to be cheaper) the same price as the householder for two good reasons—he couldn't get the business, and if he did the profits would be unreasonable.

If Jones found it necessary to give up part of his business and had his choice, which part would he drop?

CHARLES R. SEED.

Worcester, Mass.

Oil-Engine Tendencies

In the Feb. 9 issue, under the heading "Oil Engine Tendencies," Mr. Ward makes a number of statements to which I wish to take vigorous exception, based on many years of work on this subject.

OIL-FUEL SITUATION

Mr. Ward states that, since petroleum is composed of 15 per cent. gasoline, 45 per cent. kerosene, 10 per cent. high-grade distillate above 39 deg. Baumé, 10 per cent. low-grade distillate below 39 deg. Baumé, 15 per cent. lubricating oils and a remainder of 5 per cent. "slop," not over 10 per cent. is of such a nature as to require a crude-oil engine to utilize it. In Mexico, for instance, there is much oil which is of an asphaltic base and so low in volatile or refinable products as to be practically valueless for refining. The oil to which Mr. Ward referred was evidently of a paraffin base, which constitutes less than half the oil supply. If I am correct, over 60 per cent. of the raw product as drawn from the wells is available only for use in the heavy-oil engine, for generating steam, etc.

SEMI-DIESEL TYPE

It is further stated in the article that by changing from 500 to 300 lb. compression, the fuel does not burn

immediately upon entering the combustion space, as the heat of compression is insufficient to ignite it. I have demonstrated that for a running engine 150 lb. is sufficient to ignite the fuel,* the hot plate being needed only for starting in the engine which I have developed. Mr. Ward says that the semi-Diesel type should be built as heavy as the regular Diesel; further, that the maximum pressure in the semi-Diesel is 500 lb. The Diesel must have a relief valve set at from 750 to 800 lb., indicating that the pressure frequently runs to 800 lb., whereas the semi-Diesel pressures do not run over 500 lb. According to this the semi-Diesel need be built only five-eighths as strong as the Diesel. The writer's experiments would tend to indicate that an oil engine can be built which need be but little heavier or stronger than the conventional gas engine.

Two-Stroke-Cycle Type, Fuel Injection and Hot Bulb

Of these points I have little to say, except to voice the opinion that the two-stroke-cycle type can be beaten on every point by the four-stroke-cycle type. The fuel injection is still very crude and is only slightly developed from what Brayton disclosed in 1890. It seems possible to greatly improve upon the present arrangements, but my experiments along this line as yet are incomplete. Hot bulbs seem to be uncalled for and are not very practical for large sizes.

Water Injection

This is the weakest point in the semi-Diesel type. Mr. Ward says that a pressure of 300 lb. is not sufficient to ignite the fuel, and yet he mentions the use of water injection in order to keep the temperature of compression within bounds. The use of water from a thermodynamic point is as wise as it would be to propose to govern an engine by an automatic brake that would absorb the unneeded power and in this way regulate the speed of the engine. Provided the engine can first be started, the Brayton fuel injection can be used on the semi-Diesel type and the waste from the water injection can thus be avoided.

Lubrication

The writer fails to see any problem in the lubrication of the oil engine not met in the gas engine. The jacket should be used to keep the temperature at a point which is reasonably below the safe line. To go below this point is wasteful; to go above it is dangerous.

The writer got into a controversy with an engineer in the employ of the original Diesel Engine Co. of America in 1904. The point was the maximum temperature in the engine, which at that time was taken to be the temperature of compression. Temperature calculations were made from a Diesel diagram and submitted to the company. The answer was that the engine worked and that was all that the firm was interested in. The writer was interested, however, and as a result of this lack of interest on the part of the oil-engine men concerning their engine, has been able to be the first applicant in the U. S. Patent Office on many lines of development of the oil engine. There is a thermodynamics of the steam engine. In the gas engine one is limited by premature explosion, in the amount of compression carried. In the Diesel, owing to starting troubles, one is limited in the minimum compression on account of lack of ignition. The oil engine, once it is started or warmed up, can be operated on any pressure from, say 125 lb. up. The best method for getting the oil engine into a condition to avail itself of this low pressure of compression depends upon the use of the engine. For large engines there can be no better method in the opinion of the writer than to follow the practice of the steam engineers, namely, that of warming up their engines by the introduction of steam into the jackets.

John F. Wentworth.

Quincy, Mass.

*See paper by the writer presented before the last meeting of the Society of Naval Architects; also abstract of same in "Power," Jan. 26, 1915.

Driving Boilers and Bursting Tubes

Referring to the discussion of the above subject which was started by the picture and story of a burst boiler tube given in the Dec. 8, 1914, issue, page 805, the editorial comment on page 95, Jan. 19, 1915, is correct in stating that increasing the furnace heat increases the evaporation. However, Mr. Kent is right in saying that there may be times when the heat will be greater, as when the steam gets low and it becomes necessary to regain the pressure; the heat must be increased and also the evaporation, but the average evaporation remains the same.

The temperature of the water in the tube has nothing to do with overheating the tube, for the water, either hot or cold, will take up all of the heat that can be forced through the insulation of oil or scale in the tube.

The pressure has a great deal to do with the bursting of the tube, as it will require more overheating to burst the tube at low pressure than it will at high pressure.

Willis W. Nelson.

Spokane, Wash.

Trouble with Oil Separator

Referring to the query by H. G. Goodwin in the issue of Feb. 9, page 207, I would suggest that for a possible source of trouble he should examine his sewer connections. Referring to his sketch, we find that, as nearly as can be estimated, there is a difference of ten to twelve feet head in the two connections leading to the sewer. If the sewer connection is not adequate and is connected to other sources, it is possible that water backs up in the pipe leading to the oil separator in the basement until conditions allow the oil and exhaust steam to pass over into the heating system. This oil would naturally be carried into the heating system through the lower oil separator on account of the difference in head between the pipes leading from the two oil separators.

If such a condition existed the remedy would be to disconnect the exhaust from the 25-hp. engine in the basement and connect it with the same piping which leads from the 100-hp. engine on the first floor. This would remedy the trouble if the oil were passing into the heating system from the basement floor only. If oil then passed over and if the rain-leader connections from the building led into the same sewer, the remedy would be to run independent sewer connections from the oil separators and from the heating system.

W. R. Metz.

Washington, D. C.

Inquiries of General Interest

Chatter of Reducing Valve—What will cause a reducing valve to chatter?

E. H.

A reducing valve is likely to chatter if the valve is large in proportion to the use of steam at the reduced pressure. In most cases the remedy for chattering is to throttle the supply or to throttle the valve which admits low-pressure steam to the diaphragm.

Advantages of Mechanical Stokers Burning Cheap Fuel—Why are mechanical stokers better adapted for burning the cheaper grades of fuel than hand firing?

G. M.

A mechanical stoker can usually handle a lower grade of fuel because it carries a cleaner fire, the coal is fed more uniformly and the air required for combustion can be supplied at a more uniform rate.

Percentage of Output for Excitation—What percentage of output of an alternating-current generator is required for excitation?

L. H.

The excitation of a generator will vary according to the load and the voltage, but, under normal conditions and rated load, will amount to from 1 to 2 per cent. of the generator output in large machines and slightly more in smaller machines.

Weight of Cast Iron, Wrought Iron and Steel—What is the weight per cubic inch of cast iron, wrought iron and steel?

G. L.

The weight of each varies with the texture and method of manufacture. The approximate mean values used in calculations are 0.2604 lb. for the weight per cubic inch of cast iron; 0.2779 lb. for wrought iron, and 0.2834 lb. for steel, but more commonly 0.26 lb. for cast iron and 0.28 lb. for both wrought iron and steel.

Heating of Conduits Containing Wires of Polyphase Circuit—When the wires of a polyphase circuit are put in separate conduits, instead of all in one conduit as is usually done, why is it that the conduits heat?

E. D.

The greater the distance between conductors of a polyphase circuit, the greater the induction set up between these conductors, hence, the greater the heating effect thus produced. Putting the conductors in the same conduit lessens the distance between them, thereby cutting down the induction and the heating effect.

Required R.p.m. to Develop 1000 Hp.—How many revolutions per minute would be required for development of 1000 hp. by a pair of hoisting engines having cylinders 30x60 in. and a mean effective pressure of 90 lb. per sq.in.?

W. C. R.

As 1000 hp. would represent a development of

$$33{,}000 \times 1000 = 33{,}000{,}000 \text{ ft.-lb.}$$

of work per minute and as one revolution of the engine would develop

$$90 \times (30 \times 30 \times 0.7854) \times {}^{60}/_{12} \times 4 = 1{,}272{,}348 \text{ ft.-lb.}$$

then for the development of 1000 hp. the engine would have to make

$$33{,}000{,}000 \div 1{,}272{,}348 = 25.93 \text{ r.p.m.}$$

Working Pressure for Old Boiler—Is resistance of a hydrostatic test pressure 50 per cent. in excess of the working pressure proposed for an old boiler sufficient for determining the safety of the boiler operated at the proposed working pressure?

A. B.

A hydrostatic test pressure would only determine whether the boiler would probably be tight for the proposed working pressure. The working pressure should be decided from computation of the safe working strength of parts, based upon internal and external inspection before and after the hydrostatic test, with due consideration of the condition of the material and previous kind and length of service of the boiler.

Higher Efficiency with Oil than with Coal Burning—Why are higher boiler efficiencies obtainable with oil burning than with coal burning?

W. E. C.

Oil burning can be conducted with admission of but little more air than that which is required for furnishing the oxygen actually necessary, the furnace doors need not be opened while the boiler is under steam, and the boiler surfaces are not so quickly fouled with soot. In coal burning, to obtain distribution of an adequate amount of oxygen for the perfect combustion of each atom of carbon in the coal, it is necessary to introduce sufficient air to contain about double the quantity of oxygen actually required by the combustion. Therefore, in oil burning there is less loss from excessive air supply and, consequently, higher efficiency.

Difference of Water Pressure from Difference of Temperature—What would be the difference in pressure per square inch of a column of water 4 ft. high at a temperature of 40 deg. F. and at 100 deg. F.?

G. W. L.

The weight of a cubic foot of water at 40 deg. F. is 62.42 and the pressure per square inch exerted by a column 4 ft. high would be

$$\frac{62.42}{144} \times 4 = 1.733 \text{ lb. per sq.in.}$$

and as the weight of a cubic foot at 100 deg. F. is 62.02 lb. the pressure exerted by a 4-ft. column at the latter temperature would be

$$\frac{62.02}{144} \times 4 = 1.722 \text{ lb. per sq.in.}$$

and the difference of pressure would be

$$1.733 - 1.722 = 0.011 \text{ lb. per sq.in.}$$

Discharge of Steam to Vat—What will be the rate of discharge of steam at 100-lb. gage pressure from the open end of a 1-in. pipe into water contained in an open vat with the end of the pipe submerged about one foot?

W. E. P.

The rate of discharge can be approximately determined by the Napier formula for discharge of steam through an orifice into a pressure which is less than 58 per cent. of the initial absolute pressure, viz.:

$$W = \frac{A \times P}{70}$$

in which

W = Weight of steam discharged, pounds per second;
A = Area of orifice in square inches;
P = Absolute initial pressure,

according to which the discharge would be about

$$\frac{0.7854 \times (100 + 15)}{70} = 1.29 \text{ lb. of steam per second.}$$

Clattering Exhaust Valves—How can I stop the clattering noise of the exhaust valves of a noncondensing Corliss engine, which usually occurs when the engine is running light?

B. N.

The noise is probably due to the valves becoming unseated from expanding the steam below atmosphere, in which case the remedy would be to run the engine with lower initial pressure, obtained by carrying lower boiler pressure or by throttling, and thus secure higher terminal pressure. If it is not practicable to reduce the initial pressure, expansion below atmosphere can be prevented at small cost of economy by joining together the indicator connections of opposite ends of the cylinder and, having them throttled sufficiently to prevent bypassing of more steam than found barely necessary to prevent the clattering of the exhaust valves, by admission of only enough pressure from one end of the cylinder to the other to prevent expansion below atmosphere.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Commission Orders Reduction in Edison Rates

Following so closely upon Governor Whitman's investigation of the New York Public Service Commission as to imply a belated attempt to make good, the commission, after nearly four years of investigation and protracted hearings, has announced a decision in the Stadtlander case. By this the New York Edison Co. is ordered to reduce its maximum price of electricity from 10 to 8c. per kilowatt-hour. This reduction, if put in effect, will mean a saving of perhaps two million dollars annually to the large number of small consumers.

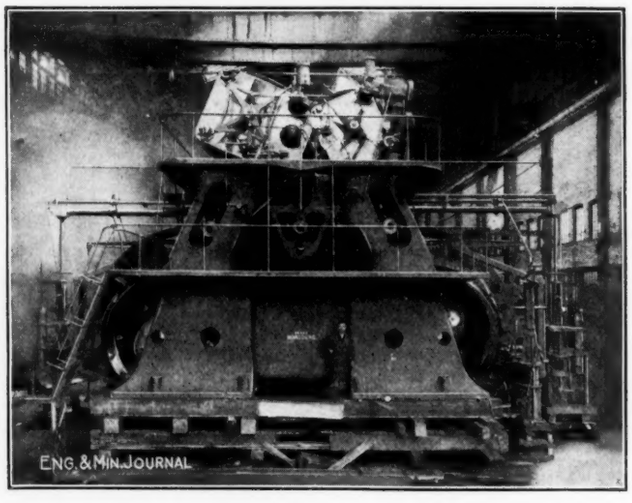
Commissioner Maltbie, who conducted the hearings, offered a resolution to reduce the price from 10 to 6½c. per kilowatt-hour, allowing the company to charge for the meters. This was voted down, 4 to 1, and Commissioner Williams' resolution for a reduction from 10 to 8c. was substituted. The former would have meant a greater saving to the large retail consumer, such as the storekeeper, but would hardly have favored the average householder as much as the recommendation adopted.

Just what action the Edison company will take in complying with the order is not known.

Large Compound Condensing Hoist

The largest compound condensing hoisting engine in the world was recently ordered by the Homestake Mining Co., and built by the Nordberg Manufacturing Co. It is of the duplex inclined cross-compound type, as shown by the side view. The two high-pressure cylinders are 28 in. in diameter and the two low-pressure 52 in., all with a common stroke of 42 in.

The hoist is built with two reels, each on a separate crankshaft. The reels are driven by axial plate clutches



NORDBERG COMPOUND CONDENSING HOISTING ENGINE

and equipped with gravity post brakes, air-operated. The hoist lifts 12,000 lb. net of ore per trip from a depth of 3200 ft. in a vertical shaft. The rope is 5/8x7¾ in., and the total rope pull is 41,900 lb.

The initial steam pressure is 150 lb. gage. All cylinders are steam-jacketed, and the exhaust pressure is maintained at 26-in. vacuum by a special design of counter-current jet condenser developed by Mr. Nordberg for hoisting-engine work. The circulating and dry-air pumps are direct-connected and driven by a simple Corliss engine.

The arrangement of this engine, having two main crankshafts connected with side rods and a reel mounted on each shaft, was necessary, owing to the topography of the ground around the shaft where this hoist is being installed. The only desirable location for the engine house bore such a relation to the shaft that the two ropes from the head sheaves to the hoist stand 12 in. center to center. With two ropes, each 7¾ in. wide and their centers 12 in. apart, it is obvious that it would be impossible to mount two reels on one shaft, as is commonly done.

The inclined cylinders and the relative position of the cranks are such as to give practically a uniform turning effort.

On small compound condensing hoisting engines working from depths of less than 1000 ft., the Nordberg company has obtained economies of less than 30 lb. of steam per shaft horsepower-hour, including the steam used by the condenser, and it is expected that the Homestake hoist will break all records for low cost of hoisting as soon as it is put in operation.—"Engineering & Mining Journal."

Unused Water Rights

What may well be helpful legislation is proposed by the Washington Water-Code Commission in a bill for the distribution of unused water rights in that state, and empowering the commonwealth to proceed by power of eminent domain to ascertain existing and proposed rights. The proposed law aims at more widespread use of the abundant waters and creates a new department under the direction of a hydraulic engineer who shall hold office for six years at an annual salary of $6000. Under the provisions of the bill an individual may exercise the power of eminent domain in the acquisition of water rights by petitioning the state which prosecutes the action in court and determines the rights of the parties.

It is urged in support of the bill that existing water titles are hazardous and that much of the water of the state is withdrawn from necessary use by the mixed condition of affairs. It is held that the state has enough unharnessed water power to furnish all the heat and power now generated by coal. Capital, it is urged, declines to develop water rights when titles are in the present precarious condition.

Extensive Water-Power Project at Millinocket, Maine

A dam fifty feet high that will flow the west branch of the Penobscot River back twenty-four miles and merge three lakes in one, is to be built this spring by the Great Northern Paper Co.

Before anything could be done toward the construction of this dam it was necessary to build a highway through the wilderness from the shore of Moosehead Lake to the gorge of Ripogenus, as in no other way could the cement and other materials be transported to the site. Two years have been occupied in building this road.

It is estimated that 40,000 to 60,000 horsepower can be developed at the gorge, but the dam is to be constructed primarily for the purpose of increasing the water-storage capacity of the west branch. The present storage capacity, estimated at 16,000,000,000 cu.ft., will be increased by the new dam to 24,000,000,000 cu.ft., while at Twin Lakes, some distance below, there has been created a storage of 15,000,000,000 cu.ft. Together, these storage basins will furnish a uniform flow throughout the year sufficient for the operation of the great pulp and paper mills at Millinocket and East Millinocket, where 1200 to 1500 men are employed and two thriving villages have grown up.

Connors Creek Plant of Detroit Edison

Before the Cleveland Engineering Society on Feb. 9, Prof. C. F. Hirshfeld gave an interesting talk on the new station now being erected by the Edison Illuminating Co., of Detroit. A brief abstract of the address follows:

A study of conditions indicated that a new plant would have to be installed and that economy and safety of distribution dictated a location about as far east of the business district as the older Delray plant is to the west of that district, with its heavy and concentrated loads. The Connors Creek site was finally selected as meeting this requirement as well as offering proper facilities for the receipt of coal and an adequate supply of circulating water.

One-third of the contemplated first plant on this site is now completed. The finished plant is designed to contain six 25,000-kv.-a. turbo-alternators and twelve 2365-hp. boilers similar to those now in use at Delray. It is probable that the turbo-alternators later installed may have greater capacity than those first contemplated.

Surface condensers, arranged for 35,000 sq.ft. of cooling surface, have been used. These condensers are so arranged that half of the tubes, with which the steam first comes in contact, contain cold circulating water. The circulating pumps are motor driven, and the air is withdrawn from the condenser by means of a motor-driven rotative dry vacuum pump arranged for two stages in one cylinder.

All auxiliaries, with the exception of the boiler-feed pumps, are electrically operated, the power being preferably taken from 1000-kw. turbo-alternators installed for that purpose. These small units and the boiler-feed pump turbines exhaust into heater condensers, the condensate from the main units being used as the circulating water for these condensers. The mixture of circulating water and condensed auxiliary steam serves as boiler feed. It is hoped that this arrangement will make possible the attainment of all of the advantages of electrically driven auxiliaries, together with the advantages accruing from the use of steam-driven auxiliaries.

Throughout the plant many innovations of a minor character have been introduced for the purpose of obtaining greater thermal and operative efficiency.

U. S. Geological Survey at the Panama Exposition

The exhibit of the United States Geological Survey at San Francisco occupies 62x78 ft. in the Palace of Mines and Metallurgy, flanked on one side by the display of the Bureau of Mines and on another by the Alaskan exhibit. The central feature is a booth, containing stage-like settings of a scene, partly modeled and partly painted. The first represents an undeveloped district in the arid West being studied by the Survey. Topographers, geologists and a stream gager are at work. The second scene shows the same district after development. The results of the stream gaging have been utilized in planning a power plant which shows in the distance and an irrigation project which covers the valley floor. A coal bed is being mined on one side; an oil field is under development elsewhere; a sandstone bed is being quarried in the foreground; mining and milling are in progress in the mountains; a town has been built, and roads, railroads and other evidences of civilization abound.

On recessed screens are shown pictures illustrating the different kinds of Survey work and the part they play in the development of the country. At one end of the space is shown the per capita production of minerals in the United States in 1880, about the time of the Centennial Exposition and of the organization of the Survey, and in 1913. A series of cases illustrate what our common things are made of, what the raw material looks like, and where it occurs in the United States; as examples, an aluminum saucepan, an electric-bulb filament and a fountain-pen point.

At the west end of the space is an exhibit of the power and fuel resources of the United States, including maps showing the distribution of the black shale from which oil is derived and the apparatus used in the field in determining the shales that are worth studying. In the portion of the exhibit relating to water resources is a display of automatic gages being run by clockwork and recording the fluctuating height of water in a tank.

Stereoscopic pictures will be arranged in boxes of fifty each, on a table at which one may sit and study various features of Survey work. There are also shown four series of pictures of the Grand Cañon and Rocky Mountain region, taken in the early days of the Geological Survey by the famous photographers, Jackson and Hillers. Other cases show the gem minerals, the rare mineral ores, etc.

Heating and Ventilation at the University of Illinois

The Department of Mechanical Engineering of the University of Illinois has been developing work along the lines of heating and ventilation, under the direction of Prof. A. C. Willard. A considerable amount of equipment for the experimental study of heating and ventilating problems has been installed within the last few months.

A recent addition consists of an air washer and humidifier specially arranged for experimental purposes. Complete control of the volume and temperature of the water circulation and of the air passing can be maintained. The washer is equipped with a double bank of spray nozzles which, by means of a finely divided mist, wash the air passing and also cool and humidify it. After passing the nozzles any entrained water in the air is removed as the air passes through a double row of V-shaped eliminators. The washer has a capacity of 3150 cu.ft. of air per minute at a velocity of 450 ft. per minute through the spray chamber. The spray water is circulated by a motor-driven centrifugal pump with a capacity of 30 gal. of water per minute at a discharge pressure of 25 lb. per sq.in.

When humidification is desired, it is necessary to saturate the air leaving the washer, and for this purpose a steam and water mixer of the injector type is installed in the tank below the spray chamber. The operation of this mixer is made to depend upon the temperature of the entrained spray water leaving the eliminator plates. A water-temperature regulator is placed in the path of the discharge from the eliminators, and this automatically operates a pneumatic diaphragm valve in the steam line leading to the mixer. Since the temperature of the saturated outgoing air and of the entrained spray water will be the same as they leave the eliminators, the regulator maintains a definite temperature of outgoing air of known humidity (100 per cent.).

The temperature of the outgoing air is also under the control of a duct thermostat which operates the pneumatic diaphragm valve supplying steam to a tempering coil placed in the inlet to the air washer. This coil makes it possible to preheat the air and determine the cooling effect or "humidifying efficiency" of the washer over a wide range of entering air temperatures. As an air washer or cleanser this apparatus is guaranteed to remove 98 per cent. of all solid matter contained in the entering air. The flow of air through the washer is induced by a multi-bladed fan with a 24-in. diameter rotor. This fan is driven through a transmission dynamometer by a variable-speed motor.

Reduction in Lighting Rates

In support of a bill to reduce residence-lighting rates from 6c. to 5c. per kilowatt hour, a schedule has been filed with the city council of Seattle of the earnings and profits of the municipal light and power plant, after having made reductions to 6c. per kilowatt hour, and a partial report of the net profits of the plant for the year 1914.

Since the beginning of 1911 the council has made four reductions in the residence-lighting schedule. About the middle of 1911 the rate was cut from 8½c. to 7c. and the minimum charge from $1 to 75c. per month, and in 1912 the rate was cut to 6c. and the minimum charge to 50c. per month.

Public Service Decisions

After careful examination by its engineers and accountants the New York Public Service Commission, Second District, has approved a method for the utilization of a large water power at Minetto, owned by the Columbia Mills, Inc., and to be leased to the Niagara, Lockport & Ontario Power Co. for use on its Syracuse and near-by lines, through the creation of a new company to develop the power. The stock of the new company, called the Northern New York Power Corporation, is to be taken by the Columbia Mills in part payment for its power. The bonds, interest and principal are also to be guaranteed by the Columbia Mills.

Though the Columbia Mills is a corporation organized under the business law, the Commission holds that, as it already sells a small amount of electricity to employees and other neighbors, it comes within the definition of an electrical corporation in the Public Service Commissions law, and as such its ownership of the stock of the other electric corporation must be approved by the Commission.

The Northern New York Power Corporation is authorized to issue $900,000 of its 6 per cent. first mortgage bonds at not less than 97 to net $873,000. Of this sum $350,000 is to be paid in cash to the Columbia Mills for its water rights, property, etc., and $455,000 is to go for the completion of the hydro-electric development. In addition, the power corporation is to issue $500,000 capital stock. This, at 125, is to be turned over to the Columbia Mills, in payment of the balance on the property transferred. The Commission further approves the lease of the new company's thus acquired and developed hydro-electric property to the Niagara, Lockport & Ontario Co.

The Commission has also approved a new link in the chain of power transmission lines in the northern part of the state, by approving franchises of the St. Lawrence Transmission Co. to extend its lines from Norfolk to Hannawa Falls, there to connect with the line of the Northern Power Co., and from Massena north to the Canadian border, where connection is made with the lines of the Cedar Rapids Transmission Co. of Canada, connecting the Cedar Rapids power with that at Hannawa Falls and elsewhere through the territory.

The Commission limits the use of these lines to transmission purposes only, through the villages of Norwood, Massena and Potsdam, and the towns of Pierrepont, Potsdam, Norfolk, Stockholm and Massena, for which the company holds franchises, but in which other local companies, such as the Norwood Electric Light & Power Co., are already doing a distributing business with the approval of the Commission.

OBITUARY

CHARLES A. SCHIEREN

Hon. Charles A. Schieren, millionaire philanthropist and once mayor of Brooklyn, died Mar. 10, of pneumonia. Mrs. Schieren, having contracted the same disease, died on the following day. Born in Rhenish Prussia in 1842, Mr. Schieren came to this country at the age of 14 with his parents, who settled in Brooklyn, N. Y. At first a cigar maker, in 1864 he went to work in the leather-belting factory of Philip F. Pasquay, in New York City. When his employer died in 1865, Mr. Schieren assumed the management of the concern and continued with the successors of the old firm until 1868, when he founded the firm of Charles A. Schieren & Co. The business grew steadily and numerous agencies were established in Europe, as well as in this country and Canada. In 1908 the Charles A. Schieren Co. was incorporated, and is today

CHARLES A. SCHIEREN

one of the greatest leather-belting concerns in the world, with factories at Ferry and Cliff St., New York City, and tanneries at Bristol, Tenn.

Mr. Schieren was chief organizer and vice-president of the Hide and Leather National Bank, president of the Germania Savings Bank and a director in the Nassau National Bank, Brooklyn Trust Co. and the Germania Life Insurance Co. He was a member of many clubs and was the chief organizer of the Brooklyn Academy of Music. During the Spanish-American War he was treasurer of the American Red Cross Society. In 1893 he was elected mayor of Brooklyn on the Republican ticket. He refused a renomination.

Mr. Schieren married Louise, daughter of George W. Bramm, in 1865. They had eight children, four of whom died. The living ones are Charles A., Jr., G. Arthur, Harry V. Schieren and Mrs. Albert H. Mathews.

PERSONALS

Prof. G. A. Goodenough, of the Department of Mechanical Engineering of the University of Illinois, recently gave a lecture on "The Development of the Steam Turbine" before the College of Engineering of the University of Wisconsin.

L. B. Marks and J. E. Woodwell, consulting engineers, 103 Park Ave., New York City, will dissolve partnership on May 1, 1915. Mr. Woodwell will locate at 8 West Fortieth St., where he will continue the general practice of consulting engineering, and Mr. Marks will remain at 103 Park Ave. and specialize, as heretofore, in illuminating engineering.

B. H. Bryant, civil engineer, has returned from Guatemala, Salvador and Honduras, where he had been locating railroad lines as chief locating engineer of the International Railways of America, and is taking a much needed vacation in Washington, D. C. Mr. Bryant, who has acted in the capacity of division engineer, chief engineer, construction engineer and general superintendent of steam railroads in the United States, Canada, Mexico, Brazil and South American countries for many years, is well known among railroad men. He expects to return to active work in the spring

ENGINEERING AFFAIRS

National Association of Master Steam and Hot Water Fitters—The twenty-seventh annual convention of this association will be held at Milwaukee, Wis., June 21-24. It is suggested that those who contemplate going to the San Francisco Exposition can very nicely arrange to attend this convention and continue on their way to California, while those who expect to attend the convention of the National Association of Master Plumbers can leave at the close of this convention and reach San Francisco in time for the other.

NEW PUBLICATIONS

SANITARY REFRIGERATION AND ICE MAKING. By J. J. Cosgrove. Technical Book Publishing Co., Philadelphia, Penn., 1915. Size, 8½x6 in.; 331 pages, 45 tables; cloth. Price, $3.50.

The author has aimed to make the treatment graphical rather than mathematical and theoretical. To persons seeking an introduction to refrigeration and ice-making this book is one of the best that has come to our attention. It will also be a good book for many operating refrigerating engineers for it is well adapted to giving them the ground-work in theory that so many need. The first fifty pages are devoted to a simple treatment of heat. We cannot recommend the book to consulting refrigeration engineers, for, obviously, if it is adapted to the needs of the operating man it cannot be well suited to the consulting engineer. For the most part the book is descriptive of the systems of refrigeration, their applications, accessories and of ice-making systems.

GRAPHIC METHODS FOR PRESENTING FACTS. By Willard C. Brinton. Published by the Engineering Magazine Co., New York, 1914. Cloth, 7x10 in.; 371 pages. Price, $4.

The engineer has a well defined and a standardized method of representing objects. The blueprint "language" has a literature satisfying the simplest as well as the most complicated needs. But very little information is available regarding the best means of showing the relations between data by the difference in the length, size and direction of lines, areas and curves. Mr. Brinton's book, which is designed to serve as a handbook in the preparing of charts and the plotting of curves, is said to be the first dealing with methods of graphical presentation. That a great deal of the subject matter appeals primarily to nontechnical readers in itself makes the book valuable to the engineer illuminating data for a non-technical audience.

Some of the methods covered are the use of vertical and horizontal bars, the comparisons of objects by their size or number, map presentations, and organization and routing diagrams. The treatment of curves, described in six of the seventeen chapters, includes their general arrangement, the advantages of comparative, cumulative and frequency curves, and suggestions for executive and financial curves.

At the end of the book are given a checking list and a set of rules for graphic presentation, the two forming practically a summary of the entire contents. The list is a set of questions with which a curve can be checked to see whether it comes up to the standard. The rules are suggested as a basis for the standardizing of graphical presentations. The chapters are logically arranged, but the headings given under the chapter numbers in the list of contents could well have been repeated in the text, thus definitely locating the particular heading.

The book will prove a useful aid to the many who hitherto, in preparing charts and curves, have depended mainly on their own ingenuity to satisfy the needs of executives as to the information in and the arrangement of the graphical reports rendered.